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OBSERVATIONS OF METEOR VELOCITIES 1931—1938

BY

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Observations of Meteor Velocities 1931—1938.

By Ernst Öpik.

1. *Purpose, Method and Arrangement of Observations.* Statistical results referring to rocking mirror observations of meteor velocities obtained in Arizona have recently been published by the author [1]. These observations were made by three different persons including the writer, whose share amounts to only about twenty per cent of all the records; certain difficulties with the calibration of the scale of velocities for the different observers presented themselves; it seemed to be advisable to obtain a more homogeneous set of observations made by a single observer, with the purpose to check the former results and possibly to work out a better method of observation with the given apparatus. It must be pointed out that the observations with the rocking mirror are especially difficult, requiring a heavy strain upon all the abilities of the observer; most of the Arizona material was obtained by two persons who had never made professional observations before, hence the need of further check is obvious. With this purpose in view the author began in the autumn of 1934 a new series of observations at Tartu, which was concluded in the spring of 1938; the new series was arranged according to a different plan as compared with the Arizona series. The essential changes consisted in the use of a fixed reticle for recording the meteor trails, instead of star maps used in Arizona, and in the neglect of observations of "shape" of the apparent oscillations; the attention of the observer was concentrated upon the record of the number of apparent waves produced in the meteor trajectory by the oscillating mirror; in other words, only the duration of flight was observed, whereas no attention was paid to other details in the visible trajectory; the reasons for such a change of method can be found in the results of the previous investigations which pointed to the superiority of the new method. The observer's attention is over-

loaded by the need of recording simultaneously a considerable number of important details, such as the position, direction, length of the trail, number of waves or duration, magnitude; in such circumstances time cannot be lost; instead of losing it in the identification of faint stars of reference, which moreover change their position during the night, it turned out to be a great help to have a permanent well-visible reticle for reference, which is especially useful in providing a definite scale for determining the length of the trail of a meteor. On the other hand, the often involuntary motion of the observer's eye following a (mostly bright and slow) meteor renders variable the subjectively observed angular velocity which equals the difference between the true velocity of the meteor and the angular velocity of motion of the eye; the apparent "shape" of the meteor trajectory, depending solely upon the above-mentioned subjective angular velocity, is therefore a less reliable criterion of meteor velocity than the number of waves which can be estimated independently of the subjective angular velocity unless the motion of the eye is set into exact coincidence with the motion of the meteor.

The results of the Tartu observations indicate that the changed method was successful, a considerably greater accuracy being obtained (as shown by the results for the shower meteors for which the observed velocities could be checked theoretically). At the same time it is a pleasure to state that the Tartu observations confirm generally the results derived from the Arizona observations. This circumstance is important because new statistical results comparable to the Arizona data are not easy to derive from the new observations which are too small in number, and comparatively unevenly distributed over the hours of the night and the time of the year, whereas the Arizona observations are much more uniform in this respect, on account of a more favourable climate. On the other hand, in the course of the reduction of the new series it was discovered that estimated durations of flight are of a high relative accuracy, not much inferior to the durations derived from the observed oscillations; in the rocking mirror procedure it is possible to observe the oscillations only for a fraction of the meteors seen, whereas for the rest — mostly at the margin of the field of vision, or faint objects — no details of the wave-shaped trajectory were visible, the meteor appearing as a hazy object of uniform motion; for the latter the

duration was estimated, as a rule, although not much of an accuracy was expected. It was a surprise to find *post factum*, from a comparison with the shower meteors, that the writer's estimated durations were reliable, after all, so that they could be used for the determination of individual velocities, too; in such a manner all meteors seen have their velocities determined; this means an increase in the statistical material available for discussion; still more important is the circumstance that the material containing all meteors seen is free from the specific selection of the velocity observer, including the troublesome $m\omega$-selection (*cf.* [1], Section 2): the data can be used for the study of the dependence of velocity upon magnitude and for other problems, without the danger of being influenced systematically by specific selection. From this standpoint the writer's observations are statistically superior to the combined Arizona observations [1], whereas the latter are superior by their uniform distribution in time as stated above.

An inquiry into old records revealed that the writer's estimates of duration made in Arizona are of a similarly high quality as those obtained at Tartu; thus a number of new velocities determined at Arizona became available; this led below to a joint discussion of all meteor velocities observed personally by the writer in Arizona and at Tartu between 1931 and 1938; the material discussed below contains altogether 785 velocities, of which 279 were previously discussed jointly with other Arizona observations [1], whereas 506 have not been used before. The author believes that his observations are superior, from the standpoint of individual accuracy, to the observations of the other Arizona observers; in any case, his scale of velocities is much better determined than the scale of the Arizona observers, as it is based upon the total of 202 shower meteors, whereas the Arizona observers R. W. and D. H. (*cf.*[1]) had only 73 shower meteors in all (among the considerable number of 1157 velocity observations); the author's data may be considered a well qualified set of observations; it is decided therefore to publish below the complete list of his velocity observations, to render them available to other workers for statistical or critical study. Although according to astronomical tradition the publication of all individual observations is highly desirable, economy in printing induced us formerly (*cf.*[1]) to refrain from this policy; we have to content ourselves with the publica-

tion of the author's observations alone, leaving unpublished the individual observations of R. W. and D. H.

After the success of the estimates of duration of E. Ö., similar estimates made by the four remaining other principal Arizona observers were investigated with the aid of shower meteors; the result was rather disappointing: none of the other Arizona observers did obtain reliable estimates of duration. As shown below, not only the accidental error is very large for these observers, but also the observed durations show so feeble a correlation with the computed ones that the impression is obtained of a set of figures written down almost at random, with little connection to the real phenomena observed. Such distressing results are also obtained from an intercomparison of simultaneous estimates of duration made by these observers. Evidently estimates of duration should be made by a well-trained observer; the success of the writer's estimates, obtained without intentional training for this particular purpose, is probably explained by a special concentration of his attention upon these estimates, perhaps together with an inborn mental sense of duration (possibly connected with the sense of musical rhythm which is able to distinguish between very small fractions of a second); eye-and-ear transit observations in which the writer had a sufficient former experience may have helped in shaping the special ability for estimates of durations. On the other hand, later experiments seem to indicate that the art of obtaining reliable estimates of the duration of short time intervals may be taught to many inexperienced persons by suitable instructions and training.

The rhythm of the oscillations of the rocking mirror apparatus does not seem to have influenced the estimates of duration; for R. W. and D. H., who partly observed without the rocking mirror, the estimates are equally unreliable with and without the apparatus; at the same time these observers succeeded in obtaining acceptable observations of velocity with the rocking mirror, observations which the writer considers more difficult (although more accurate also) than simple estimates of duration; it seems that the above-mentioned observers did not care much for the estimates.

Estimates of duration are as a rule used in the determination of the velocities of fire-balls, in which case, however, the durations are considerable, mostly of the order of several seconds,

therefore more easy to judge upon than the durations of "ordinary" fainter meteors which range from $0^s.1$ to $0^s.6$, seldom more. The estimates of meteor durations have, nevertheless, been used several times, by Hoffmeister, Fisher, Maltzev, but only in the form of mean values from a large number of observations. The present results indicate that good estimates can be used individually and may still compete with rocking mirror observations when suitable calibration of the velocities with the aid of shower meteors is available; we notice on this occasion that naked-eye observations of velocities at the rocking mirror cannot yet do without such a calibration, too, and even for the more accurate telescopic observations of velocities the calibration appears to be highly desirable (although more difficult to obtain); thus, the only advantage of the rocking mirror determinations of velocities, as compared with good estimates of duration, seems to consist in a somewhat smaller accidental error of the former; with respect to errors in the length of the trail (which seem to represent the chief source of error in velocity) the two methods are of equal reliability.

The usefulness of the estimates of duration of "ordinary" meteors seems to have been recognized by Astapovič and other observers in Russia who check the accuracy by simultaneous observations; no comprehensive discussion of such observations has yet been published there.

Several times there have been raised objections to the use of reticles in meteor observations; the objections have come from workers who are chiefly concerned with the determination of radiants and who are accustomed to the use of fixed stars for reference (*cf.* the critical remarks by Olivier in Popular Astronomy, June-July, 1938, and the reply by Öpik, ibidem, May 1939); it is true that radiants are determined most accurately through observations made around and near the expected position of the radiant, which cannot be efficiently accomplished by reticles fixed with respect to the horizon; but the critics forget that routine radiant determinations have never been the purpose of the investigations planned by the writer and that the statistical and other results obtained by him have been made possible only by the homogeneous sets of data furnished by observations referred to fixed reticles. In one respect the critics are right: the number of recorded meteors is smaller with a reticle

than without it; this is partly explained by the shading effect of the reticle wires, perhaps by the one-eyed vision, chiefly, however, by the limitation of the field of vision; the latter circumstance is a positive rather than a negative factor, as it means the exclusion of a number of objects badly observed at the edge of the field of vision. In the Tartu observations the shading effect of the wires was considerably reduced by using much thinner wires than in Arizona. As to the relative efficiency of monocular and binocular vision, the writer is not in a position to decide upon the question from personal experience, as he lost his left eye long before he started astronomical observations; but the large percentage of common objects appearing in simultaneous reticle observations speaks in favour, instead against the "feeling of reality" in this case; possibly some faint badly seen objects may be systematically omitted, which is again only an advantage from the standpoint of accuracy; as to the fatigue of the eye, some trouble may arise at the beginning for an inexperienced person accustomed to using both eyes; the inconvenience, however, soon disappears and the observer learns to appreciate the opportunity of giving rest in turns to one or the other eye. The accuracy in position and length of the trail certainly gains by the reticle, whereas only the errors in direction are possibly increased by the use of the reticle as compared with an unrestricted observer who uses a free-hand ruler to fix the direction. The reticle furnishes a smaller number of items, but a much greater amount of useful new information.

The principles of the construction of the rocking mirror apparatus are described briefly in connection with the first announcement of the work of the Arizona Expedition (*cf.*[2], pp. 19—20) where it is called the "double-pendulum apparatus"; further details referring to the method in use in Arizona can be found in [3] and [1].

The same apparatus was lent to the writer by Harvard College Observatory and could thus be used at Tartu for observations which are discussed in the present paper. Slight alterations in the apparatus were made; considering that the frequency of the alternating current was now fifty periods per second (in Arizona the frequency was sixty per second), the old gear was substituted by a new one reducing in the ratio 1:5, in such a manner that the frequency of the oscillations of the mirror was ten per second,

the same as before. A second gear in the ratio 1 :10 was additionally constructed which transmitted the motion to a bar that beat audibly whole seconds and helped to verify the speed of the oscillation; it turned out that the speed of the electric motor was practically constant in all cases but one, within the accuracy of the control ($0^s.1$ in 20 seconds, or one-half per cent); in one case the speed was for some reason smaller, equal to three-fifths of the normal speed, in which case the corresponding correction was of course introduced. It may be added that the ear is rather sensitive to small alterations in the speed of the oscillation, which circumstance does not make it necessary to control very often the speed by a time-keeper.

The reticle of reference of 45^0 inclination was attached to the outside of an ordinary window frame; beneath the reticle the rocking mirror apparatus (which occupies a space of only about $20 \times 20 \times 20$ cm) was placed on a board, the mirror in a horizontal position, in such a manner that the mirror-edge was separated from the window glass by not more than 1—2 mm; the observer looking into the mirror through the window glass from the inside of the room sees the reflection of the sky upon which the threads of the reticle appear as dark lines. A rectangular paper diaphragm was pasted on the window glass just above the level of the mirror, its purpose being to fix the position of the eye and to avoid the error of parallax of the reticle threads; the diaphragm was wide enough to leave open the entire field of vision, being still narrow enough to remain vaguely visible just outside the field, i. e. outside the contours of the mirror; the centering of the eye was most efficienty accomplished by observing the reflection of the reticle which had to take always the same position with respect to the contour of the mirror while the eye was directed towards the centre of the reticle. Of course, a slight residual error of parallax must have remained, of the order of $\pm 0^0.5$, caused by the displacement of the eye with respect to its average position; namely the eye must be constantly moved, sweeping irregularly the inner portion of the field of vision; the error is partly accidental, partly systematic, depending upon the position of the observed object; the systematic component of the parallax error is automatically taken into account by the method of reduction based upon observations of stellar positions, whereas the accidental error is small, influencing by an unimportant amount

the absolute position of the trail, leaving the direction and the length of the trail practically unaffected.

In Arizona the reticles were made to imitate celestial equatorial coordinates, which circumstance doubtlessly simplifies the reductions; however, the disadvantage of these reticles which had to be prepared of comparatively thick iron bars, consists in a sensible shading effect; further, the complicated structure of the polar reticles in Arizona (concentric rings crossed by straight bars emanating from the pole) led to more frequent mistakes in the observed position as compared with the equatorial reticles which did not much differ from a rectangular pattern. All these considerations together with the simplicity of construction and control led the author to choose a simple rectangular pattern for the Tartu reticle; in the reticle plane, placed at an effective distance of 38 cm from the eye, threads of about 1.5 mm width were subtended, the mesh of the pattern equalling nearly 9^0 at the centre. The two central threads were reinforced to render them easily distinguishable. The meteor trails were traced on maps of the reticles reduced to the scale of 3 cm a reticle square, or one-half of the original.

The rectangular field of vision extended over 64^0 in the horizontal direction and 43^0 in the vertical one; the vertical extension of the field was smaller than in Arizona because the window glass did not allow the eye to be placed very near to the mirror. This circumstance, as well as the absorption by the window glass may have caused some loss in the hourly number of meteors, which loss, however, is doubtlessly more than counterbalanced by the comfort of observations made in a heated room; hoar-frost depositing on the inside of the window glass at low winter temperatures was easily removed by ventilation, the observer using his hand as a fan, the radiation of heat from the observer's face helping to the same effect. The observations were made at the author's quarters placed at the outskirts of the town of Tartu where city lights did not much interfere with the observations; however, the building development in this particular district proceeded at such a rate that at the conclusion of this series of observations noticeable inconvenience from lights was already felt, which circumstance is also reflected in the number of meteors registered per hour. The horary rate was low as a rule, because so many factors caused loss: the absorption in the mirror glass,

at the double passage of the beam to and from the silvered rear side of the mirror; the absorption in the window glass and in the glasses of the observer who is short-sighted; the reduction in size of the field of vision; very often the haziness of the sky, the frequency of occurrence of which was unfortunately unusual for Tartu during the period of observations. Especially the latter circumstance renders the observations not well adapted for the derivation of the hourly frequency of the meteors. Therefore, the statistical problems which may be attacked on the basis of the present material are the relative distribution and mutual correlation of the velocities, directions, magnitudes, without trying to derive absolute frequencies in space and time.

The position of the reticle was changed in the course of the observations; from September, 1934, to August, 1936, the reticle was centered slightly west of north, at declination $+70^{0}.6$ and hour angle $129^{0}.8$ W, covering thus the north polar region; from September, 1936, to April, 1938, the reticle was attached to another window facing south-west, covering an equatorial region centered at declination $+16^{0}.8$, hour angle $28^{0}.6$ W.

2. *Reduction of Observations.* In the case of the Tartu observations, the rectangular coordinates x, y for the beginning and the end of the meteor trail were measured on the maps. Observations of a number of star positions were also made; their true celestial coordinates being known, the observed rectangular coordinates could be used to determine the constants of the formulae of transition from rectangular to celestial coordinates; in other words, the reference stars were used to determine the orientation and scale of the reticle. The problem is similar to the photographic determination of stellar positions on wide angle photographs; owing to the considerable angular extent of the reticle, simplifications in the formulae of spherical trigonometry, ordinarily made for limited fields, cannot be used.

Considering the map a gnomonic, or central projection of the sky and the reticle, the radius of projection being R (distance of the plane of projection from the centre), the following formulae determine the transition from the measured rectangular coordinates (x, y) to the spherical equatorial coordinates (AR, δ, 1936. 0):

$$d = \sqrt{x^2 + y^2} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (1),$$

$$\operatorname{tg}\gamma = \frac{y}{x} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (2),$$

the quadrant of γ being defined by

$$\cos\gamma = \frac{x}{d} \quad . \; . \; . \; . \; . \; . \; (2'); \text{ further}$$

$$\operatorname{tg} D = \frac{d}{R} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (3),$$

$\sin\delta = \sin\delta_0 \cos D + \cos\delta_0 \sin D \cos(\gamma + C)$ . . (4), or

$$\sin\left(45^0 - \frac{\delta}{2}\right) = \sqrt{\sin^2\frac{(D+\delta_0-90^0)}{2} + \cos\delta_0 \sin D \sin^2\frac{(\gamma+C)}{2}} \ldots (4'),$$

$$\sin(\Theta - \Theta_0) = -\frac{\sin D \sin(\gamma + C)}{\cos\delta} \quad . \; . \; . \; . \quad (5), \text{ or}$$

$$\cos(\Theta - \Theta_0) = \frac{\cos D - \sin\delta_0 \sin\delta}{\cos\delta_0 \cos\delta} \quad . \; . \; . \; . \; . \; . \quad (5');$$

finally

$$AR = \Theta + S \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (6).$$

Here D ist the angular distance from the centre of the reticle, δ_0 the declination, Θ_0 the hour angle of the centre, S the sidereal time expressed in degrees; the constant parameters of the above equations were determined from the reference stars as follows:

$R = 190$ mm; $C = +55^0.2$ for the northern orientation, $+68^0.8$ for the south-western one; $\delta_0 = +70^0.6$, $\Theta_0 = 230^0.2$ (northern); $\delta_0 = +16^0.8$, $\Theta_0 = 331^0.4$ (south-western). The observed positions of the reference stars (thirty observations north, twelve southwest) are represented by the above formulae with a probable error of $\pm 0^0.54$, which includes the accidental error of parallax; the meteor positions must no doubt be somewhat less accurate.

The zenith distance, needed in the calculation of velocity, is determined graphically. We have

$$\cos z = \sin\delta \sin\varphi + \cos\delta \cos\varphi \cos\Theta \quad . \; . \; . \; . \quad (7).$$

For the given latitude, $\varphi = +58^0.4$, and for constant δ equation (7) may be represented by the straight line

$y = a + bx$, where $y = \cos z$, $x = \cos\Theta$, $a = \sin\delta \sin\varphi$, $b = \cos\delta \cos\varphi$; $\cos z$ for the beginning and the end of the trail was read off from graphs constructed on the above principle.

The length of the trail, L, was computed either from

$$\sin\frac{L}{2}=\sqrt{\sin^2\frac{(\delta_1-\delta_2)}{2}+\cos\delta_1\cos\delta_2\sin^2\frac{(AR_1-AR_2)}{2}} \quad . \quad . \quad (8),$$

or in most cases (when $AR_1-AR_2<20^0, \delta_1-\delta_2<20^0$) from the approximate formula

$$L=\sqrt{(\delta_1-\delta_2)^2+(AR_1-AR_2)^2\cos\delta_1\cos\delta_2} \quad . \quad . \quad (8').$$

All calculations according to the above formulae were checked by approximate graphical methods, to avoid mistakes; the check was made directly on the original maps of the observations, using transparent graphs.

The zenithal magnitude, m_z, is calculated for the Tartu observations with the aid of Table I, which includes the effect of absorption (*cf.* [5]); the form of a "critical table" is adopted here.

Table I.

Reduction of Meteor Magnitudes to the Zenith.

Δm	$\overline{\cos z}$	Δm	$\overline{\cos z}$	Δm	$\overline{\cos z}$	Δm	$\overline{\cos z}$
	1.000		0.730		0.530		0.386
0.0		−0.8		−1.6		−2.4	
	0.978		0.701		0.508		0.371
−0.1		−0.9		−1.7		−2.5	
	0.939		0.672		0.488		0.357
−0.2		−1.0		−1.8		−2.6	
	0.901		0.647		0.469		0.343
−0.3		−1.1		−1.9		−2.7	
	0.865		0.621		0.451		0.330
−0.4		−1.2		−2.0		−2.8	
	0.829		0.597		0.433		0.318
−0.5		−1.3		−2.1		−2.9	
	0.795		0.574		0.417		0.306
−0.6		−1.4		−2.2		−3.0	
	0.763		0.551		0.401		0.295
−0.7		−1.5		−2.3			
	0.730		0.530		0.386		

The zenithal magnitude is given by

$$m_z=m+\Delta m \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (9),$$

where Δm is to be taken from Table I.

As to the methods of reduction of the Arizona observations, they have been described in former publications (*cf.* [1] and the works cited there).

The angular velocity of the meteor is determined on the basis of the length of trail and observed number of waves from

$$\omega = \frac{f L_n}{(0.1n)} \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10),$$

where n ist the whole number of oscillations, L_n the length of the portion of the trail which is covered by the n waves; generally $0.1\ n < \tau < 0.1\ (n + 1)$, τ denoting the total duration; n and L_n were determined on the original drawing by marking the point nearest to the end of the trail which seemed to correspond to the same phase of the oscillation as the beginning; f is the personal correction factor, found equal to 0.832 for the Tartu velocities derived from observed oscillations; the factor, determined from fifty-three shower meteors, includes the systematic errors of observation, drawing, computation(judgment upon n and L_n), as well as the systematic error in the adopted heights of the shower meteors. For the Arizona observations of the writer the factor f was found equal to 0.938 (*cf.*[3]); owing to the different methods, especially to possible systematic differences in the length of the trail as observed with, and without a reticle, the difference in f is not surprising.

In the case of estimated durations the angular velocity is determined from

$$\omega = \frac{f' L}{\tau} . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (10'),$$

where τ is the estimated duration, L the total observed length of the trail, and f' a special correction factor generally variable with τ as given in Table II; the data for the Arizona estimated durations are published for the first time.

Table II.

Correction Factors (f) of the Angular Velocity (ω) in the Case of Estimated Duration (τ).

τ sec	0.05	0.08	0.10	0.12	0.15	0.2	0.3	0.4	0.5	0.6	0.8	1.0
f', Tartu	0.62	0.72	0.73	0.75	0.79	0.83	0.86	0.92	0.96	1.00	1.00	1.00
f', Arizona	$f' = 0.848 =$ const.											

The factor f' was determined from thirty-five shower meteors for the Tartu series, and from forty-five for the Arizona observations.

The observed angular velocity is reduced to the zenith, neglecting the curvature of the earth:

$$\omega_z = \frac{\omega}{\overline{\cos z}} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (11),$$

where $\overline{\cos z}$ ist the mean of $\cos z$ for the beginning and the end of the trail. The zenithal angular velocity, ω_z, represents the angular velocity at a distance from the observer equal to the mean height H of the trail, for the same linear tangential velocity as actually observed.

When the angular velocity is expressed in deg/sec, the linear tangential velocity T in km/sec is determined from

$$T = \frac{H\omega_z}{57.3} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \; . \quad (12),$$

H being given in kilometers.

For a shower meteor of geocentric velocity U, observed at the distance λ from the radiant, the tangential velocity is

$$T = U \sin \lambda \quad . \; . \; . \; . \; . \; . \; . \; . \quad (13);$$

from (13), (12) and (11) we find the computed, or predicted angular velocity of a shower meteor:

$$\omega_c = U \sin \lambda \, \overline{\cos z} \; . \frac{57.3}{H} \quad . \; . \; . \; . \quad (14);$$

the equivalent of it is the predicted duration τ_c adapted to the observed length of the trail, L:

$$\tau_c = \frac{L}{\omega_c} \quad . \; . \; . \; . \; . \; . \; . \; . \; . \quad (14').$$

The average heights of the shower meteors in equation (14) as well as the mean heights as function of ω_z and m_z in (12) were assumed on the basis of the Arizona observations of heights exactly in the same manner as described in [1], except that the Tartu hypothetical heights were increased by the constant amount of 1.9 km, corresponding to the difference of level between the Arizona stations and Tartu. There may be a small systematic error in the adopted heights caused by climatic differences, which however is automatically taken into account by the reduction factors f and f'. The actually used values of the height factors for Tartu are given in Table III.

Table III.

Assumed Values of $\frac{H}{57.3}$ for Tartu,

Mean of the Year.

ω_z deg/sec	1.5	5.0	9.0	13.0	17.0	20.5	24.0	28.0	≥ 30.0
m_z					$\frac{H}{57.3}$				
4.5	1.50	1.54	1.57	1.59	1.62	1.66	1.68	1.70	1.71
3.5	1.48	1.52	1.55	1.57	1.60	1.63	1.66	1.68	1.69
2.5	1.45	1.49	1.52	1.54	1.57	1.60	1.63	1.65	1.66
1.5	1.43	1.47	1.50	1.52	1.55	1.58	1.61	1.63	1.64
0.5	1.40	1.44	1.47	1.49	1.52	1.55	1.58	1.60	1.61
—0.5	1.38	1.42	1.45	1.47	1.50	1.53	1.56	1.58	1.59
—1.5	1.35	1.39	1.42	1.44	1.47	1.50	1.53	1.55	1.56
—2.5	1.33	1.37	1.40	1.42	1.45	1.48	1.51	1.53	1.54
—3.5	1.30	1.34	1.37	1.39	1.42	1.45	1.48	1.50	1.51
—4.5	1.28	1.32	1.35	1.37	1.40	1.43	1.46	1.48	1.49
—5.5	1.26	1.30	1.33	1.35	1.38	1.41	1.44	1.46	1.47

The factors f and f' are supposed to represent the true correlation between the observed and the computed or true angular velocities; to judge rightly our system of velocities this circumstance must be kept in mind; we have not used simply the regression line of ω_c upon ω observed *) (or τ_c upon τ), which might have seemed the most natural procedure to follow, especially because so many examples of this sort are known from astrophysical practice (e. g., spectroscopic absolute magnitudes); the regression line of ω observed upon ω_c is much closer to the true correlation than the first mentioned regression line, because ω_c as a basis of selection contains a smaller accidental error than ω observed; the true correlation lies between the two regression lines, being nearer to the second than to the first. Our velocities derived with the aid of correction factors found upon the above described principle may be considered to be "directly observed quantities" with respect to observational errors, remaining "sta-

*) Which means the determination of the average ω_c for given ω observed, the latter thus figuring as the basis of selection.

tistical mean values" only from the standpoint of the adopted mean hypothetical heights. The statistical consequences of these facts have been considered mathematically in a former paper (*cf.*[1], Section 5).

3. *The Observations.* Table IV contains the Tartu observations obtained by the author; the table contains 233 rocking mirror observations of velocity (observed oscillations), 146 cases of estimated duration and one case without velocity, when only the meteor train was observed; the relatively large proportion of observed oscillations, considerably outnumbering the cases of estimated duration, may be noted. The table is arranged in such a manner that two lines correspond to each item, in order to reduce the horizontal extent of the table. The 1-st column gives the catalogue number and the uncorrected estimated magnitude, m. In the 2-nd column the upper line refers to t , the local mean solar time, whereas the lower line gives at the left m_z, the zenithal magnitude, and the identification of the radiant at the right in case the meteor is assumed to belong to a shower; the list of the radiants with their notation is given below. The 3^{d} column refers to the duration; the upper figure is derived from the number of oscillations, the lower figure is estimated; only in rare cases both lines are filled at once. The 4th, 5th and 6th columns contain the hour angle, the right ascension, and the declination, the upper figures referring to the beginning, the lower ones — to the end of the trail. In the 7th column the upper line contains the observed length of the trail, the lower one — the mean cosine of the zenith distance of the beginning and the end. The upper line in the 8th column gives the inferred angular velocity, calculated according to (10) or (10′); in the case of estimated duration ω is printed in parentheses, to make easier the distinction between the two methods used in the determination of velocity; the lower line of the 8th column contains T_g, the tangential component of the orbital velocity of the earth at the observed position of the centre of the meteor trail; this is a purely computational quantity. In the 9th column T (upper figure) is the observed tangential velocity of the meteor, according to (12) and (11); we notice that equation (12) together with Table III (referring to all meteors) have been used for all meteors, including those assumed to belong to showers, whereas the standardization of our velocities (factors f, f') was

Table IV.
Meteor Velocities Observed at Tartu, 1934—1938.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Sep. 8/9, 1934						
1	1^h22^m	$0^s.26$	233°2	241°1	80°.4	6°.5	19.2	41.2	53	
3.5	2.8 ...	...	201°.3	209°.2	77°.7	.760	29	276°	309°	
				Sep. 9/10, 1934						
2	22 08	0.15	238.0	198.3	61.0	5.5	30.9	83.3	55	
3.0	1.8 ...	...	246.9	207.2	57.8	.610	30	166	158	
3	23 33	0.13	219.2	200.7	61.5	3.5	19.2	60.0	54	
2.8	1.2 ...	...	218.2	199.7	58.0	.525	30	244	274	
4	23 51	0.35	269.9	256.0	77.0	4.0	8.0	15.4	37	
3.5	3.0 ...	...	252.4	238.5	76.7	.810	30	285	336	
				Sep. 10/11, 1934						
5	21 26	0.06	186.9	137.7	78.2	1.5	5.0	9.8	37	
0.5	—0.3 ...	<0.1	185.3	136.1	76.7	.720	27	343	355	
6	21 31	0.12	169.9	121.9	76.7	1.9	13.8	31.9	58	
3.8	3.0 ...	...	164.2	116.2	75.5	.705	26	3	2	
7	21 53	0.44	249.1	206.6	70.3	5.3	8.7	19.1	37	
3.5	2.6 ...	...	239.1	196.6	66.5	.700	30	275	329	
8	22 10	...	233.3	195.1	46.5	4.4	(10.1)	44.5	34	
4.0	1.5 ...	0.4	233.2	195.0	42.1	.370	30	228	271	
9	22 14	0.23	198.9	161.7	78.3	2.9	9.2	19.7	44	
3.5	2.7 ...	...	191.0	153.8	76.0	.720	28	312	340	
10	22 34	0.15	269.0	236.7	51.2	4.1	20.8	54.1	26	
4.0	3.0 ...	...	272.2	239.9	47.7	.650	29	170	158	
11	23 03	0.34	160.1	135.1	68.0	7.4	17.3	49.6	69	
1.0	—0.4 ...	...	155.2	130.2	60.9	.555	25	312	328	
12	23 41	0.20	250.0	234.4	55.6	5.7	23.7	67.9	89	
4.0	2.7 ...	...	239.9	224.3	56.4	.580	30	305	321	
13	23 47	0.34	240.6	226.5	69.6	11.2	26.5	67.2	56	
2.0	0.9 ...	...	230.7	216.6	59.2	.635	30	237	263	
14	0 04	0.15	213.2	203.5	64.8	6.2	34.4	99.4	73	tr.2s
0.8	—0.7 ...	...	217.6	207.9	59.0	.550	30	203	212	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Sep. 10/11, 1934						
15	0^h16^m	$0^s.17$	266°.6	259°.9	68°.9	7°.0	29.4	65.6	45	
3.5	2.8 ...	...	257°.9	251°.2	62°.9	.745	30	217°	241°	
16	0 48	0.65	266.2	267.3	55.7	9.2	10.6	26.1	38	
4.0	2.9 ...	...	250.1	251.2	54.8	.640	29	268	317	
17	0 51	0.12	206.0	207.9	67.3	5.7	36.5	105.9	110	
2.5	1.1 ...	...	196.5	198.4	63.2	.565	30	270	286	
				Sep. 11/12, 1934						
18	22 09	...	173.1	135.5	75.1	3.5	(14.5)	34.9	58	
3.5	2.5 ...	0.2	163.3	125.7	72.9	.665	26	323	339	
19	22 47	...	175.0	147.0	58.1	9.0	(20.7)	77.3	51	
2.0	—0.1 ...	0.4	190.5	162.5	55.3	.425	27	193	200	
				Sep. 12/13, 1934						
20	23 10	0.13	207.9	186.7	87.8	4.8	29.7	59.7	54	
2.0	1.5 ...	...	212.4	191.2	83.0	.815	28	245	273	
21	23 28	0.35	249.2	232.4	67.0	4.7	9.9	22.6	39	
4.0	3.1 ...	...	238.7	221.9	65.0	.685	30	275	325	
22	23 40	...	249.5	235.6	65.9	3.7	(10.6)	24.5	39	
3.2	2.3 ...	0.3	241.6	227.7	64.4	.680	30	271	321	
23	0 01	4.1	163.9	155.3	54.0	52.9	10.9	44.2	24	
3.0	0.7 ...	4.0	245.2	236.6	41.5	.395	30	149	110	
24	0 20	0.35	250.7	246.9	58.3	12.3	28.6	76.9	52	
3.0	1.8 ...	...	261.9	258.1	47.9	.610	29	157	144	
				Sep. 13/14, 1934						
25	23 03	0.36	190.0	168.0	64.4	8.6	19.3	62.9	44	
2.5	0.8 ...	...	200.2	178.2	57.3	.495	28	220	243	
26	23 18	0.14	242.2	223.8	69.8	5.2	25.3	60.4	34	
3.8	2.9 ...	...	245.2	226.8	64.7	.695	30	201	218	
27	23 34	...	130.4	116.0	73.1	6.3	(26.1)	63.7	60	
3.0	2.1 ...	0.2	146.5	132.1	69.5	.680	25	250	273	
28	0 03	0.48	288.0	280.9	65.7	16.1	27.5	55.4	25	tr.1s
—0.5	—1.1 ...	...	279.8	272.7	50.2	.775	30	179	178	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Sep. 13/14, 1934						
29	0^h12^m	$0^s.14$	$290^0.4$	$285^0.5$	$58^0.3$	$7^0.0$	36.8	76.9	48	
2.0	1.4 ...	...	$285^0.6$	$280^0.7$	$51^0.9$	.785	29	188^0	194^0	
				Sep. 14/15, 1934						
30	21 37	...	221.5	178.9	52.8	4.2	(17.4)	67.9	50	
4.0	1.9 ...	0.2	224.4	181.8	49.1	.420	30	223	247	
31	1 53	0.13	225.1	246.5	74.7	5.6	37.2	89.8	60	
4.0	3.1 ...	...	227.7	249.1	69.2	.700	30	185	188	
32	2 03	0.13	233.3	257.2	75.1	5.8	42.8	100.8	74	
3.7	2.9 ...	...	228.9	252.8	69.4	.705	30	201	210	
33	2 38	0.32	182.1	214.9	70.3	5.4	13.1	36.2	30	
3.5	2.2 ...	...	179.9	212.7	65.0	.590	30	232	285	
				Sep. 15/16, 1934						
34	22 31	0.37	248.8	220.6	58.5	15.8	35.9	94.8	66	
—0.5	—1.8 ...	...	262.3	234.1	45.0	.590	29	179	179	
35	22 32	0.38	241.1	213.1	67.1	5.1	10.5	25.9	36	
4.5	3.5 ...	...	234.4	206.4	62.8	.650	30	260	315	
				Sep. 16/17, 1934						
36	0 50	0.31	246.8	254.5	61.0	12.2	31.0	90.9	68	
3.2	1.8 ...	...	240.2	247.9	49.4	.560	29	208	220	
				Oct. 4/5, 1934						
37	22 13	...	108.9	95.2	76.9	3.6	(14.9)	28.0	27	tr.1s
1.5	1.0 ...	0.2	93.2	79.5	78.2	.810	25	119	64	
38	0 49	0.15	244.3	269.6	57.4	5.0	21.9	65.6	51	
3.5	2.1 ...	...	239.2	264.5	53.3	.555	29	227	253	
39	1 04	0.10	130.7	159.7	85.3	10.8	89.9	193.9	174	
3.0	2.4 ...	...	186,4	215.4	77.3	.770	28	221	227	
40	1 14	0.37	226.0	257.6	60.6	8.0	17.1	54.1	27	
4.0	2.4 ...	...	233.2	264.8	53.6	.525	30	164	145	
				Oct. 7/8, 1934						
41	21 31	0.36	224.7	202.3	59.5	7.1	15.0	46.1	27	
1.5	—0.1 ...	...	231.0	209.6	53.6	.515	29	213	250	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_o m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Oct. 7/8, 1934						
42	22h07m	...	278°.7	266°.3	75°.7	4°.3	(22.7)	46.5	55	
4.0	3.5 ...	0s.15	264°.1	251°.7	73°.7	.820	30	269°	303°	
43	22 20	...	241.8	232.6	46.0	9.9	(22.8)	90.0	60	
4.0	1.8 ...	0.4	250.4	241.2	38.4	.415	30	180	180	
44	23 20	...	253.4	259.1	51.7	10.6	(27.0)	80.3	51	
1.0	—0.5 ...	0.35	259.9	265.6	42.0	.535	29	175	172	
45	23 31	...	39.3	47.9	87.0	12.4	(35.5)	68.1	41	
3.5	3.2 ...	0.3	303.7	312.3	79.6	.880	28	169	160	
46	1 06	...	110.4	142.6	78.6	4.7	(15.6)	32.8	44	
4.0	3.4 ...	0.25	122.4	154.6	74.8	.775	26	278	313	
47	1 54	...	218.9	263.1	72.6	3.8	(27.7)	66.3	89	
2.8	1.9 ...	0.1	206.5	250.7	73.5	.685	30	311	326	
48	1 56	...	122.9	167.6	70.2	9.8	(40.7)	85.7	73	tr.1s
—2.0	—2.7 ...	0.2	133.9	178.6	79.6	.730	26	127	111	
49	2 07	0.35	214.0	261.5	79.0	7.2	15.1	33.8	39	
3.5	2.7 ...	...	191.8	239.4	73.9	.715	30	255	304	
				Oct. 8/9. 1934						
50	23 30	0.84	215.5	225.0	54.7	5.0	5.0	18.5	34	
3.8	1.6 ...	...	210.3	219.8	50.8	.410	30	268	329	
51	0 00	0.26	252.1	269.1	50.3	4.7	13.9	43.5	17	
3.5	1.9 ...	...	252.2	269.2	45.6	.520	29	193	217	
52	0 06	0.16	277.9	296.4	56.2	4.5	24.3	52.8	26	
1.5	0.8 ...	...	280.7	299.2	52.0	.740	29	164	146	
53	0 52	0.15	208.3	238.0	74.4	3.0	13.4	30.9	4	
3.5	2.6 ...	...	216.4	246.1	72.7	.695	30	173	100	
54	1 03	0.13	248.6	281.3	67.5	2.7	17.4	39.8	61	
2.0	1.2 ...	...	241.7	274.4	68.3	.705	30	300	325	
55	2 00	0.13	207.1	253.8	79.0	6.0	33.9	78.7	52	
3.2	2.4 ...	...	211.6	258.3	73.1	.715	30	198	208	
56	3 24	0.11	226.6	294.6	70.9	5.8	45.0	115.9	88	
4.0	2.9 ...	...	221.2	289.2	65.5	.645	30	197	203	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	to m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 8/9, 1934					
57	3^h26^m	...	116°.3	184°.5	75°.4	4°.6	(33.6)	75.9	53
3.3	2.6 ...	$0^s.1$	130°.7	108°.0	72°.9	.735	28	207°	222°
				Oct. 10/11, 1934					
58	23 31	0.65	263.2	274.9	60.3	5.0	5.7	11.9	34
4.2	3.5 ...	...	273.9	285.6	62.0	.740	30	83	20
				Oct. 12/13, 1934					
59	23 19	0.15	196.3	206.8	76.0	5.6	29.5	72.5	59
3.8	2.9 ...	...	203.9	214.4	70.8	.675	29	232	254
60	23 22	0.45	251.6	262.9	56.5	8.9	14.8	44.1	42
4.2	2.8 ...	...	241.9	253.2	49.8	.555	30	246	287
61	23 39	0.35	252.4	267.9	62.0	13.3	28.4	70.8	42 Tr.1s*)
—0.5	—1.6 ...	...	258.7	274.2	49.2	.625	29	179	179
62	23 39	0.29	128.7	144.2	72.2	12.2	34.9	75.0	49 Tr.1s*)
—0.5	—1.3 ...	...	170.7	186.2	79.8	.725	26	175	172
63	23 42	0.54	201.5	217.8	68.5	6.7	10.2	28.9	36
3.8	2.4 ...	...	198.4	214.7	61.9	.555	29	256	308
				Oct. 14/15, 1934					
64	3 51	0.10	201.0	281.5	60.5	2.7	22.5	77.7	50
3.0	1.2 ...	...	200.7	281.2	57.8	.475	30	196	206
65	4 01	0.15	278.0	361.0	63.0	5.7	30.5	66.6	41
3.0	2.3 ...	...	272.3	355.3	58.0	.760	30	158	142
				Oct. 29/30, 1934					
66	21 56	0.55	208.5	215.1	66.9	6.5	9.2	24.9	41
0.5	—0.9 ...	...	205.5	212.1	60.5	.555	29	279	323
67	22 18	0.35	236.8	248.8	66.9	9.1	20.4	54.8	54
3.0	1.8 ...	...	231.4	243.4	58.2	.610	30	253	285
				Nov. 4/5, 1934					
68	19 31	...	164.5	140.6	62.0	4.3	(14.3)	47.6	60
3.5	1.8 Ra	0.25	170.9	147.0	59.0	.490	20	300	317

*) Double meteor, difference in time 2^s.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	to m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 4/5, 1934					
69	19^h41^m	$0^s.65$	$167^0.3$	$146^0.1$	$71^0.6$	$12^0.2$	14.2	29.9	9
—1.0	—1.8 ...	...	$164^0.4$	$143^0.2$	$83^0.8$	.715	26	163^0	108^0
70	20 43	1.23	253.8	247.9	58.4	17.8	12.1	35.7	35
2.0	0.5 Rb	...	250.3	244.4	40.7	.535	30	244	294
				Nov. 27/28, 1934					
71	18 44	0.35	236.2	223.4	66.3	7.5	15.0	39.8	57
4.0	2.8 ...	...	234.5	221.7	58.8	.615	28	291	318
72	18 55	...	270.1	259.9	62.4	4.6	(19.1)	40.4	11
3.5	2.9 ...	0.2	278.9	268.7	60.5	.770	30	188	210
73	19 38	0.35	294.9	295.4	63.1	8.3	18.8	36.9	42
2.5	2.0 ...	...	286.5	287.0	56.0	.825	30	257	301
74	19 41	0.32	227.8	229.2	68.3	7.1	18.4	47.8	66
1.5	0.3 ...	...	226.1	227.5	61.2	.615	29	292	317
				Nov. 28/29, 1934					
75	18 57	...	154.5	145.8	72.1	23.5	(9.4)	21.6	28
1.5	0.5 ...	2.5	224.7	216.0	67.1	.650	26	254	315
76	19 08	...	254.1	248.2	58.7	5.3	(22.0)	54.1	25
3.5	2.6 ...	0.2	263.9	258.0	57.7	.675	30	186	195
77	19 23	0.45	246.8	244.5	56.7	8.5	15.3	45.0	47
4.0	2.6 ...	...	249.9	247.6	48.4	.560	30	256	294
78	19 36	0.11	189.9	191.0	74.1	4.6	34.1	85.2	89
4.0	3.0 ...	...	201.6	202.7	71.1	.665	27	268	286
79	20 06	...	161.2	169.8	56.6	8.2	(8.2)	31.4	38
2.0	—0.3 ...	1.0	174.2	182.8	53.3	.400	22	268	304
80	21 31	0.53	196.9	226.8	83.3	10.8	16.6	37.2	51
2.0	1.2 ...	...	200.8	230.7	72.5	.720	29	281	315
81	22 22	0.11	230.8	273.4	63.9	3.6	27.0	74.7	66
4.0	2.8 ...	...	230.5	273.1	60.3	.600	30	242	265
82	22 31	0.35	203.3	248.2	64.6	7.4	16.0	51.1	47
3.0	1.4 ...	...	207.9	252.8	57.5	.515	30	246	282

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec T_g km/sec	T km/sec P	T_0 km/sec P_0	
			Nov. 30/Dec. 1, 1934							
83	18h45m	0s.35	203°.5	193°.8	81°.8	5°.6	11.6	24.3	46	
3.0	2.3 ...	...	214°.0	204°.3	76°.5	.750	29	301°	334°	
84	19 35	...	229.5	232.3	59.3	3.5	(8.1)	23.4	32	
3.0	1.5 ...	0.4	232.6	235.4	56.2	.535	29	256	317	
85	19 50	...	192.9	199.4	74.9	6.1	(8.7)	20.6	47	
3.0	2.0 ...	0.7	183.5	190.0	69.5	.650	27	350	356	
86	19 58	...	218.7	227.2	61.0	5.2	(21.6)	69.5	90	
3.5	1.9 ...	0.2	216.0	224.5	56.0	.510	28	308	322	
87	20 52	...	205.7	227.9	56.6	6.9	(19.8)	74.5	57	
4.0	2.0 ...	0.3	215.6	237.6	52.8	.435	28	223	243	
88	21 45	0.25	245.9	281.2	67.3	5.4	18.0	43.7	34	
3.5	2.6 ...	...	247.4	282.7	61.9	.680	30	231	274	
89	22 09	0.63	206.4	247.6	85.7	13.7	18.1	39.9	49	
3.0	2.3 ...	...	208.5	249.7	72.0	.740	30	268	306	
90	22 35	0.20	110.5	148.3	78.6	10.6	44.1	89.8	63	
3.5	3.0 ...	...	167.3	215.1	87.2	.815	29	198	206	
91	23 23	...	150.8	210.7	64.8	12.0	(15.0)	49.2	50	tr.1s
2.0	0.3 ...	0.8	165.7	225.6	55.3	.490	27	256	288	
92	0 12	0.11	231.2	303.2	77.8	4.3	33.2	70.8	43	
1.5	0.8 ...	...	242.6	314.6	74.4	.755	29	170	163	
93	0 26	0.26	281.8	357.3	57.1	4.2	11.6	24.2	39	
3.0	2.3 ...	...	274.2	349.7	58.0	.755	28	278	323	
94	0 34	0.15	222.0	299.7	70.0	5.0	32.1	80.8	56	
3.5	2.5 ...	...	233.6	311.3	67.3	.660	30	153	140	
95	0 36	...	272.0	350.0	75.8	11.3	(37.5)	76.9	47	tr.1s.5
2.0	1.5 ...	0.25	270.0	348.0	64.5	.800	30	179	179	
96	0 42	...	185.7	265.2	72.3	15.0	(28.8)	86.6	80	
3.0	1.5 ...	0.5	188.3	267.8	57.4	.545	30	245	265	
97	1 31	...	220.1	311.9	76.4	6.7	(35.3)	85.2	87	
4.0	3.1 ...	0.15	201.5	293.3	72.0	.700	30	263	282	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	to m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 30/Dec. 1, 1934					
98	1^h41^m	$0^s.40$	231°.4	325°.8	59°.5	9°.1	19.0	62.5	48
2.0	0.3 ...	...	222°.6	317°.0	51°.8	.490	28	228°	254°
				Dec. 1/2, 1934					
99	19 00	...	171.1	166.3	81.3	4.8	(19.9)	42.8	49
4.5	3.9 ...	0.2	139.1	134.3	81.1	.770	29	96	60
100	19 32	0.74	222.8	225.7	57.9	5.2	5.5	17.0	45
3.5	1.8 ...	...	213.5	216.4	56.5	.490	28	11	5
101	19 42	0.25	146.7	152.4	74.1	5.0	14.5	34.5	57
3.0	2.0 ...	...	139.0	144.7	69.7	.670	27	41	22
102	20 06	...	95.8	107.2	75.0	5.0	(14.4)	27.3	53
0.0	—0.6 ...	0.3	115.3	126.7	75.0	.790	29	318	340
103	20 08	0.10	250.7	262.9	69.5	3.3	27.5	64.0	45
5.0	4.3 ...	...	255.7	267.9	66.8	.735	30	220	245
104	20 49	0.25	231.0	253.3	66.9	2.5	6.9	16.3	43
4.0	3.0 ...	...	226.6	248.9	68.8	.650	30	46	15
105	21 29	0.85	193.1	225.4	70.0	7.8	7.2	18.8	39
2.0	0.6 ...	...	192.6	224.9	62.2	.570	28	293	334
106	21 33	...	175.1	208.4	51.8	10.0	(12.5)	58.5	34
4.0	1.4 ...	0.8	191.2	224.5	51.6	.350	27	201	216
107	21 37	...	192.8	227.2	68.7	4.3	(5.4)	14.1	42
3.5	2.2 ...	0.8	184.4	218.8	65.9	.580	28	342	354
108	21 56	...	239.1	278.0	60.3	4.6	(19.1)	54.1	79
4.0	2.7 ...	0.2	230.2	269.1	59.2	.585	30	319	334
109	22 21	...	234.2	279.5	63.3	6.7	(11.2)	31.4	47
3.5	2.1 ...	0.6	226.1	271.4	57.9	.570	30	280	319
110	22 34	...	234.1	282.7	52.1	7.4	(8.2)	30.2	44
3.5	1.4 ...	0.9	227.0	275.6	46.3	.430	30	274	317
				Dec. 5/6, 1934					
111	20 10	...	249.6	266.0	63.0	14.3	(9.5)	24.9	41
1.5	0.2 ...	1.5	242.2	258.6	49.3	.580	30	278	323

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	to m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Dec. 5 6, 1934						
112	20^h18^m	$0^s.25$	$147^0.2$	$165^0.6$	$72^0.5$	$6^0.5$	18.6	45.3	42	
2.5	1.5 G	...	$169^0.3$	$187^0.7$	$73^0.4$	.670	28	245^0	282^0	
113	20 22	...	233.8	253.2	63.0	4.4	(12.6)	34.2	46	
4.0	2.7 ...	0.3	233.4	252.8	58.6	.590	30	273	313	
114	20 25	0.24	199.8	220.1	59.1	3.3	10.8	37.0	64	
3.5	1.7 ...	...	193.9	214.2	57.9	.470	27	353	355	
115	21 36	...	258.8	296.7	62.0	7.5	(39.5)	97.1	72	
3.5	2.6 ...	0.15	264.8	302.7	55.2	.680	29	201	210	
116	22 09	0.13	161.8	208.0	61.0	4.1	30.2	103.2	128	
2.5	0.7 ...	...	159.0	205.2	57.2	.470	27	336	341	
117	22 57	0.15	321.1	379.3	83.1	5.8	29.5	55.6	31	
3.0	2.7 G	...	294.2	352.4	79.0	.880	30	205	229	
118	23 08	...	182.3	243.2	60.0	4.4	(14.6)	53.1	42	
3.5	1.5 G	0.25	187.8	248.7	56.7	.450	29	232	265	
119	23 30	0.64	202.0	268.6	79.0	7.0	8.2	17.2	37	*)
0.0	—0.9 ...	...	190.6	257.2	72.6	.700	30	281	333	
120	23 46	...	125.8	196.2	80.0	3.8	(15.8)	33.3	48	
3.5	2.8 ...	0.2	139.8	210.2	77.3	.760	29	281	317	
121	0 32	0.19	135.9	217.8	67.7	5.9	24.5	62.2	35	
3.0	1.9 ...	...	148.9	230.8	71.5	.645	29	165	152	
122	0 47	0.42	283.1	368.8	44.3	10.3	20.0	52.0	47	
2.0	0.8 G	...	269.7	355.4	41.1	.620	24	245	272	
123	0 59	...	193.0	281.7	69.8	5.1	(37.2)	100.6	77	
4.5	3.4 ...	0.1	206.9	295.6	69.4	.625	30	148	136	
124	1 03	0.15	231.1	320.8	60.8	5.0	25.8	78.0	54	
3.5	2.0 ...	...	230.4	320.1	55.8	.545	28	207	221	
125	1 24	0.15	247.3	342.2	45.6	2.6	15.1	54.3	32	
3.0	1.1 ...	...	246.8	341.7	43.0	.455	23	189	196	
126	1 25	...	251.4	346.6	62.8	4.7	(19.5)	48.9	22	
3.0	2.0 ...	0.2	250.1	345.3	58.1	.655	28	191	205	

*) Burst —1 mag at end.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Dec. 5/6, 1934						
127	1^h54^m	$0^s.15$	$201^0.5$	$303^0.9$	$77^0.8$	$6^0.9$	33.9	77.8	66	
—1.0	—1.9 G	...	$195^0.9$	$298^0.3$	$71^0.1$	.680	30	237^0	259^0	
				Dec. 6/7, 1934						
128	20 04	...	184.1	200.1	75.7	3.6	(14.9)	32.9	61	
—1.0	—1.9 ...	0.2	173.6	189.6	73.5	.680	29	25	14	
129	22 17	0.42	243.8	293.0	65.2	12.6	24.5	66.4	57	
2.5	1.3 G	...	241.0	290.2	52.7	.605	30	239	266	
130	23 06	0.12	206.7	268.1	71.4	4.6	28.0	73.0	56	
3.5	2.4 ...	...	212.7	274.1	67.3	.635	30	226	248	
131	23 35	0.14	286.5	355.2	74.7	6.7	35.7	68.9	49	
1.0	0.6 G	...	273.3	342.0	69.3	.835	30	217	238	
132	0 09	0.34	248.1	325.3	54.2	3.4	7.6	20.9	43	
4.0	2.6 ...	...	242.4	319.6	55.0	.560	27	310	338	
133	0 23	...	304.2	385.0	80.9	4.4	(18.3)	33.7	9	
4.0	3.7 ...	0.2	297.1	377.9	76.8	.885	30	165	108	
				Dec. 8/9, 1934						
134	22 02	...	288.4	335.8	65.7	3.8	(20.0)	38.8	24	tr.$0^s.5$
2.0	1.6 ...	0.15	284.7	332.1	62.3	.830	28	218	264	
135	22 06	0.41	218.8	267.2	70.1	9.8	19.6	51.6	35	
3.5	2.4 ...	...	232.1	280.5	61.9	.630	30	220	254	
				Dec. 11/12, 1934						
136	20 04	0.52	226.6	247.4	56.7	9.7	14.7	48.3	38	
2.5	0.8 G	...	237.4	258.2	49.5	.490	30	232	270	
137	20 12	0.68*	270.8	293.8	46.3	9.2	11.1	29.6	43	
—1.0	—2.4 ...	...	262.7	285.7	39.3	.555	27	278	316	
138	20 26	0.90*	288.4	314.9	60.2	13.6	12.6	25.9	28	
2.0	1.3 G	1.2	279.4	305.9	47.6	.755	28	244	306	
139	22 46	0.30	118.5	179.8	78.4	7.3	20.2	43.6	34	
3.0	2.4 G	...	156.2	217.5	79.0	.765	29	232	274	

* These durations are extrapolations from a portion of the trail, for which the oscillations were noticed.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Dec. 11/12, 1934					
140	23^{h}04^m	...	272°.9	338°.8	65°.2	3°.8	(20.0)	43.8	26
4.0	3.4 ...	0^s.15	270°.0	335°.9	61°.6	.765	28	214°	251°
141	23 06	0.35	258.4	324.8	55.3	9.5	21.6	61.0	43
3.0	1.7 ...	...	255.6	322.0	46.0	.580	26	217	238
				Dec. 12/13, 1934					
142	23 29	0.14	278.7	351.8	69.0	4.8	30.0	62.3	51
3.5	3.0 G	...	269.2	342.3	65.9	.800	29	236	265
143	23 30	0.15	185.9	259.3	77.0	3.3	17.1	40.1	33
3.5	2.6 G	...	193.4	266.8	74.3	.695	30	232	280
144	23 35	0.25	252.1	326.7	69.6	5.1	14.1	31.5	26
3.5	2.7 G	...	247.3	321.9	64.8	.715	29	231	291
145	23 40	...	174.9	250.9	79.4	9.0	(5.0)	11.1	35
3.5	2.6 ...	1.8	170.7	246.7	70.4	.685	30	286	342
146	0 10	0.15	277.7	1.0	48.2	4.8	21.8	55.3	46
3.0	2.0 G	...	271.7	355.0	45.7	.650	24	236	262
147	0 17	0.24	254.1	339.3	50.6	8.1	27.6	87.9	65
3.0	1.4 ...	...	253.1	338.3	42.5	.515	25	198	205
148	0 33	...	227.0	316.1	50.2	4.6	(15.3)	63.1	49
3.0	0.7 ...	0.25	225.3	314.4	45.7	.390	26	228	251
149	0 47	...	162.8	255.4	65.2	11.7	(19.5)	64.7	62
0.0	—1.8 G	0.6	169.0	261.6	53.9	.470	30	252	278
150	0 52	...	139.4	233.4	69.0	6.4	(18.3)	49.8	60
3.5	2.3 ...	0.3	141.1	235.1	62.6	.610	29	273	302
151	0 54	0.15	194.5	288.9	80.4	4.5	18.7	40.8	37
1.0	0.2 G	...	194.9	289.3	75.9	.725	30	241	286
152	1 00	...	228.9	324.7	61.3	5.9	(16.9)	52.5	38
4.0	2.5 G	0.3	225.5	321.3	55.7	.535	28	224	255
153	1 13	0.36	261.8	0.9	64.7	6.6	13.7	31.1	25
2.0	1.1 G	...	250.7	349.8	60.5	.695	28	229	288
154	1 20	0.10	230.3	331.2	88.0	3.2	26.6	54.4	36
4.0	3.5 G	...	219.1	320.0	84.9	.825	30	219	250

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Dec. 12/13, 1934						
155	1^h26^m	...	248°.6	350°.9	41°.6	4°.8	(11.0)	44.6	40	
3.5	1.2...	$0^s.4$	242°.9	345°.2	39°.6	.400	22	243°	272°	
156	1 30	...	289.5	33.0	71.3	3.0	(18.8)	36.9	33	
4.0	3.6 G	0.12	280.0	23.5	71.4	.845	30	238	288	
157	1 56	0.13	194.4	304.2	79.1	3.5	20.6	47.7	56	
4.0	3.2 G	...	183.9	293.7	76.4	.725	30	269	301	
158	1 58	...	289.9	40.4	66.2	5.2	(21.6)	43.7	38	
3.5	3.1 G	0.20	277.0	27.5	66.5	.830	30	239	281	
159	2 06	...	257.1	9.6	72.1	4.5	(18.7)	41.2	39	*)
4.0	3.3 G	0.2	243.5	356.0	70.9	.755	30	245	289	
160	2 06	0.32	178.2	290.7	77.6	8.7	21.9	51.3	45	*)
0.0	—1.9 G	...	177.2	289.7	68.9	.665	30	241	276	
161	2 09	...	199.4	312.7	71.7	6.0	(17.2)	46.2	32	
3.5	2.3 G	0.3	197.9	311.2	65.7	.615	30	222	262	
162	2 13	0.15	164.4	278.4	65.7	3.6	24.5	75.1	66	
3.0	1.5 G	...	165.3	279.3	62.1	.535	30	242	266	
163	2 17	0.34	265.8	21.0	51.7	5.1	11.6	30.0	24	
3.0	1.8 G	...	258.3	13.5	49.8	.610	26	229	285	
164	2 24	...	226.2	343.1	54.0	4.1	(17.0)	60.2	68	
2.5	0.6....	0.2	219.4	336.3	53.5	.455	27	275	299	
165	2 27	...	162.3	280.0	59.5	4.0	(11.4)	40.0	27	
3.0	1.0 G	0.3	164.3	282.0	55.6	.450	30	222	271	
166	2 38	...	196.4	316.9	59.5	5.2	(12.0)	43.1	40	
1.5	—0.5 G	0.4	191.4	311.9	55.0	.440	28	244	284	
				Jan. 3/4, 1935						
167	18 46	0.49	236.3	260.5	63.4	4.2	7.5	17.5	13	
2.8	1.8 Q	...	244.8	269.0	65.6	.650	30	173	10	
168	19 45	...	172.2	211.0	87.7	3.8	(10.9)	19.7	21	
3.0	2.6 Q	0.3	45.0	83.8	88.0	.850	30	137	40	

*) These two meteors separated in time by only 2^s.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Jan. 3/4, 1935						
169	19h59m	...	228°.9	271°.3	76°.6	5°.7	(16.3)	33.6	18	
3.5	2.9 Q	0s.3	252°.8	295°.2	79°.7	.775	30	148°	85°	
170	20 04	...	230.9	274.6	60.6	3.0	(6.9)	18.0	12	
4.0	2.7 Q	0.4	237.0	280.6	60.5	.590	30	190	348	
171	20 06	0.35	234.8	278.9	63.7	4.5	9.3	21.8	8	
2.0	0.9 Q	...	244.8	288.9	63.1	.635	30	187	340	
172	20 18	0.24	267.5	314.5	57.2	5.5	17.7	40.6	14	
3.0	2.2 Q	...	275.5	322.5	54.1	.710	28	190	210	
173	20 19	...	181.5	228.8	57.8	0.0	0.0	0.0	30	*)
—0.5	—2.5 Q	0.6	181.5	228.8	57.8	.440	30	...	0	
174	21 28	...	179.7	244.3	64.9	4.4	(4.9)	11.9	20	
0.0	—1.3 Q	0.90	185.1	249.7	68.8	.580	30	156	14	
175	21 38	...	272.5	339.7	77.1	4.5	(18.7)	37.3	18	
3.5	3.1 ...	0.2	273.2	340.4	72.6	.830	29	210	260	
176	21 50	...	173.2	243.2	74.4	3.2	(13.3)	31.0	22	
4.0	3.1 Q	0.2	175.6	245.6	77.5	.700	30	138	71	
177	22 10	...	240.4	315.4	43.5	8.4	(16.1)	67.6	44	
3.5	1.2 Q	0.5	248.7	323.7	38.0	.390	24	194	202	
				Jan. 7/8, 1935						
178	23 13	0.10	228.0	322.8	72.9	3.1	25.8	63.2	62	
4.0	3.1 ...	...	224.9	319.7	70.0	.690	30	255	282	
				Jan. 8/9, 1935						
179	20 46	0.43	260.9	319.9	69.5	2.5	4.4	8.5	36	
3.0	2.4 ...	...	258.1	317.1	71.8	.775	29	40	9	
180	21 01	...	263.9	326.6	65.4	5.4	(28.4)	65.1	74	
2.5	1.7 ...	0.15	256.1	318.8	61.3	.715	28	277	299	
181	22 05	...	168.3	247.1	62.9	4.6	(15.3)	45.2	20	tr.1s
0.5	—1.0 ...	0.25	178.5	257.3	63.8	.535	30	200	231	

*) Stationary meteor.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Jaan. 8/9, 1935						
182	22^h46^m	$0^s.35$	77°.5	166°.5	83°.7	5°.7	12.4	21.9	51	
0.0	—0.4 ...	...	105°.2	194°.5	79°.6	.835	30	332°	347°	
183	23 27	0.33	230.8	330.1	69.3	7.4	17.5	42.4	17	
2.0	1.0 ...	...	239.8	339.1	62.8	.660	28	196	224	
184	23 40	0.33	207.0	309.5	59.3	4.3	9.8	33.7	47	
3.0	1.1 ...	...	203.6	306.1	55.7	.460	29	278	316	
185	23 42	...	244.0	347.0	70.9	6.3	(14.5)	34.2	42	
4.0	3.1 ...	0.4	231.4	334.4	66.6	.690	28	264	306	
186	23 56	...	265.3	11.8	55.7	6.2	(11.8)	28.6	42	
3.5	2.4 ...	0.5	254.4	0.9	55.5	.645	24	284	317	
				Jan. 9/10, 1935						
187	1 44	0.12	235.8	10.2	50.6	3.6	26.0	98.1	76	
3.0	1.0 ...	...	235.8	10.2	47.1	.450	22	190	193	
188	2 27	...	293.6	78.9	63.7	7.6	(31.5)	62.6	51	
2.5	2.1 ...	0.2	291.4	76.7	56.2	.835	28	127	101	
				Jan. 10/11, 1935						
189	0 16	...	96.3	209.8	78.5	8.5	(62.0)	121.0	94	
3.0	2.6 ...	0.10	69.1	182.6	86.4	.850	30	160	154	
190	0 48	...	288.1	49.5	64.2	13.0	(54.0)	116.4	92	
3.0	2.4 ...	0.2	272.9	34.3	53.9	.770	26	195	200	
191	2 13	0.20	251.6	34.3	58.3	7.7	32.0	87.8	70	
1.0	—0.3 ...	...	241.8	24.5	52.9	.580	24	214	225	
192	2 35	...	267.3	55.5	52.0	4.4	(32.1)	85.3	62	
3.5	2.4 ...	0.10	264.4	52.6	48.0	.625	24	168	164	
193	3 47	0.25	291.6	98.2	52.4	11.1	35.9	79.7	51	
1.5	0.7 ...	...	276.4	83.2	46.9	.725	29	171	166	
194	4 18	0.15	263.3	77.4	72.0	1.7	10.1	20.5	18	
4.0	3.4 ...	...	257.7	71.8	72.1	.785	29	218	316	
				March 2/3, 1935						
195	22 25	0.35	250.4	26.3	48.0	3.0	6.4	19.9	33	Tr.1s
3.5	1.8 ...	...	247.7	23.6	45.6	.490	21	288	326	
196	22 47	0.10	237.6	19.2	73.4	3.1	25.8	61.0	68	
4.0	3.2 ...	...	230.4	12.0	71.2	.715	26	274	297	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				March 3/4, 1935					
197	21^h51^m	$0^s.15$	$261^0.2$	$29^0.6$	$45^0.8$	$2^0.0$	8.7	25.1	42
3.5	2.0 ...	...	$258^0.6$	$27^0.0$	$45^0.0$	.540	21	313^0	334^0
198	22 33	0.46	106.8	245.8	86.4	8.5	14.6	28.6	42
3.0	2.5 ...	...	175.7	314.7	81.2	.800	29	273	317
199	22 38	...	186.4	326.6	79.9	3.2	(9.2)	19.6	46
3.8	3.1 ...	0.3	177.7	317.9	77.2	.735	29	325	346
200	1 02	0.33	179.8	356.0	78.2	8.4	19.9	48.1	43
2.5	1.6 ...	...	188.0	4.2	70.1	.675	27	241	275
				March 4/5, 1935					
201	20 56	0.33	258.8	14.4	67.3	10.4	25.1	56.3	38
3.0	2.3 ...	...	271.2	26.8	58.5	.740	24	211	230
202	1 08	0.15	120.4	299.2	70.8	4.1	17.8	41.2	40
2.5	1.6 ...	...	130.8	309.6	68.8	.695	30	246	290
203	1 14	0.35	173.2	353.4	74.7	5.2	11.4	26.4	4
3.0	2.1 ...	...	192.4	12.6	73.9	.680	27	172	70
204	1 27	...	166.0	349.4	63.5	4.2	(13.9)	44.8	36
3.5	1.8 ...	0.25	171.5	354.9	60.2	.505	28	232	271
205	3 01	....	359.4	206.4	83.8	6.6	(27.4)	48.8	37
—1.0	—1.3 ...	0.2	115.8	322.8	89.2	.875	28	228	262
				March 5/6, 1935					
206	22 02	0.34	197.8	330.9	65.2	3.1	7.2	20.3	42
3.5	2.0 ...	...	197.1	330.2	62.1	.540	29	295	335
207	2 24	0.45	231.0	69.7	72.6	5.5	9.6	20.8	14
3.5	2.7 ...	...	241.1	79.8	68.2	.710	23	143	64
208	3 08	...	313.8	163.5	76.8	17.3	(71.8)	146.0	120
4.0	3.6 ...	0.2	251.0	100.7	70.9	.830	26	190	192
209	3 50	0.20	168.9	29.2	67.7	4.2	17.5	49.8	30
2.0	0.6 ...	...	173.2	33.5	63.9	.565	24	204	224

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t_o m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
			March 7/8, 1935						
210	22^h27^m	$0^s.14$	$265^0.5$	$46^0.9$	$56^0.5$	$3^0.8$	17.0	42.6	42
3.0	2.0 ...	...	$262^0.2$	$43^0.6$	$53^0.2$	.655	20	254^0	282^0
211	22 38	...	261.0	45.2	77.5	6.9	(19.8)	41.1	47
2.5	1.9 ...	0.3	244.0	28.2	72.2	.775	25	267	300
212	0 46	0.55	224.9	41.1	77.1	8.8	12.7	28.1	42
2.5	1.6 ...	...	201.2	17.4	71.0	.700	26	278	316
213	0 49	0.12	291.0	107.9	58.2	2.1	12.4	24.3	27
3.5	3.0 ...	...	287.2	104.1	58.8	.815	19	257	300
			March 8/9, 1935						
214	1 41	...	209.7	40.7	69.7	4.0	(21.1)	57.5	36
4.5	3.3 ...	0.15	213.9	44.9	66.0	.620	23	194	203
215	3 50	0.15	232.1	95.2	73.6	6.0	26.5	64.2	41
3.0	2.1 ...	...	225.1	88.2	68.0	.685	23	189	194
			April 3/4, 1935						
216	23 06	0.32	88.7	266.4	80.8	4.8	12.1	22.8	41
3.5	3.0 ...	...	117.3	295.0	79.9	.820	29	283	328
			April 5/6, 1935						
217	21 44	...	137.8	297.2	87.9	7.7	(19.6)	37.7	14
3.0	2.6 ...	0.35	287.0	86.4	84.1	.850	28	197	234
			Aug. 28/29, 1935						
218	21 54	...	288.6	233.3	82.3	3.8	(18.1)	34.0	46
2.5	2.1 ...	0.17	263.9	208.6	80.9	.850	29	272	312
219	22 11	...	247.5	196.5	76.8	2.3	(5.3)	10.5	35
4.0	3.4 ...	0.4	237.4	186.4	75.8	.765	29	295	345
220	22 55	0.40	170.2	130.1	71.2	8.7	18.1	47.0	26
2.0	0.8 ...	...	193.2	153.1	67.9	.615	27	206	234
			Sep. 4/5, 1935						
221	22 50	0.35	271.9	237.6	57.7	11.4	25.3	58.7	30
0.5	—0.4 ...	...	274.2	239.9	46.4	.685	29	181	182
222	23 00	...	247.5	215.6	42.5	5.1	(3.4)	12.6	38
4.0	1.8 ...	1.5	240.7	208.8	41.7	.405	30	299	342

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	to m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Sep. 4/5, 1935						
223	0^h18^m	$0^s.10$	269°.0	256°.7	69°.7	6°.7	55.7	120.0	93	
4.0	3.4 ...	...	273°.6	261°.3	63°.3	.785	30	160°	154°	
224	0 43	0.20	133.8	127.7	73.9	8.6	35.8	80.4	56	
2.5	1.7 ...	...	164.4	158.3	78.8	.730	27	159	148	
225	1 09	0.11	217.6	218.0	66.2	8.9	67.3	189.4	159	
1.0	—0.4 ...	...	224.8	225.2	58.0	.565	30	183	184	
226	1 18	0.15	265.3	267.9	74.4	9.7	56.2	120.5	91	
2.0	1.4 ...	...	256.8	259.4	65.1	.765	30	188	191	
				Sep. 22/23, 1935						
227	22 03	...	162.8	134.3	70.3	3.3	(6.3)	14.1	18	tr.
0.0	—1.1 ...	0.5	165.2	136.7	73.5	.645	25	138	33	
228	23 05	...	99.4	86.4	79.6	8.8	(16.9)	34.5	54	
2.5	1.9 ...	0.5	123.2	110.2	73.2	.775	25	310	330	
229	23 07	...	238.5	226.0	50.6	2.9	(8.3)	26.7	39	
1.0	—0.9 ...	0.3	235.1	222.6	48.7	.465	30	265	315	
230	23 14	0.36	196.9	186.2	63.4	3.3	7.2	21.4	34	
3.0	1.4 ...	...	192.3	181.6	60.9	.510	20	291	325	
231	23 31	...	151.8	145.3	60.1	8.2	(34.0)	117.4	95	tr.
3.0	1.2 ...	0.2	165.4	158.9	58.1	.475	25	205	212	
232	0 11	0.12	211.5	215.0	75.1	4.3	27.5	66.6	56	
3.0	2.1 ...	...	210.9	214.4	70.8	.685	29	237	262	
				Oct. 23/24, 1935						
233	22 39	0.82	298.8	310.0	72.8	6.6	6.7	11.9	37	*)
3.0	2.6 ...	...	276.2	287.2	74.8	.860	30	294	342	
234	22 42	...	209.8	221.6	61.3	7.4	(14.2)	49.1	49	
2.5	0.6 ...	0.5	208.9	220.7	53.9	.465	29	253	287	
235	22 54	0.84	234.4	249.4	63.2	20.0	19.8	58.4	30	
2.5	1.0 ...	...	249.7	264.7	45.2	.550	30	191	202	

*) Duration extrapolated from the portion of trail for which the oscillation was observed.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Oct. 23/24, 1935,						
236	23^{h}06^m	0^s.23	298°.3	316°.1	65°.4	5°.1	17.6	33.3	50	
3.8	3.4 . . .	. . .	286°.2	304°.0	66°.6	.860	30	283°	318°	
237	23 12	0.65	234.9	254.2	76.0	18.2	22.0	50.6	25	
1.5	0.6 . . .	. . .	251.5	270.8	58.8	.700	30	198	221	
238	23 30	0.38	132.7	156.6	68.0	10.5	22.8	55.6	35	
—1.0	—2.1 . . .	. . .	161.5	185.4	68.7	.630	25	205	223	
239	23 31	. . .	168.7	192.8	84.7	2.7	(5.2)	9.9	35	
4.5	4.0 . . .	0.5	138.8	162.9	85.0	.805	27	39	10	
240	23 48	0.36	220.5	249.0	56.1	8.1	17.5	63.8	35	
3.0	1.0 . . .	. . .	227.6	256.1	49.2	.450	30	189	196	
241	23 56	. . .	218.5	249.0	64.8	10.9	(27.7)	82.1	55	
1.5	0.0 . . .	0.35	226.3	256.8	54.6	.540	30	201	212	
242	0 16	. . .	173.4	208.7	64.9	15.8	(30.3)	99.4	71	tr.
1.0	—0.8 . . .	0.5	199.7	235.0	55.5	.485	29	191	196	
				Nov. 1/2, 1935						
243	3 11	0.25	231.9	320.0	51.8	3.4	10.1	35.7	39	
3.5	1.6 Ra	. . .	226.6	314.7	51.0	.455	28	253	296	
244	3 45	0.56	278.7	15.2	88.4	8.8	13.0	25.0	34	
3.0	2.5 Ra	. . .	136.9	233.4	82.5	.820	28	260	314	
245	3 52	0.24	248.6	346.9	76.5	4.8	16.0	33.2	38	
2.0	1.4 Ra	. . .	227.7	326.0	76.6	.765	30	252	301	
246	4 03	0.34	143.7	244.6	80.4	3.7	8.1	16.0	42	
3.0	2.4 . . .	. . .	124.8	225.7	78.9	.775	29	317	344	
247	4 08	0.24	262.3	4.5	50.7	6.8	21.0	60.4	31	
2.5	1.1 . . .	. . .	255.2	357.4	45.8	.570	30	185	190	
				Nov. 3/4, 1935						
248	2 18	0.45	240.5	317.1	61.7	7.2	12.6	33.8	37	
3.0	1.7 Rb	. . .	227.1	303.7	59.0	.590	29	251	299	
249	2 59	0.14	192.6	279.5	63.2	5.6	32.6	110.2	85	
3.5	1.7 . . .	. . .	192.9	279.8	57.6	.485	29	205	214	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	to m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Nov. 3/4, 1935						
250	3^h02^m	$0^s.25$	$151^0.3$	$239^0.0$	$77^0.5$	$4^0.5$	13.6	31.6	21	
4.0	3.1 . . .	. . .	$158^0.8$	$246^0.5$	$73^0.4$	.700	29	221^0	285^0	
251	3 31	0.27	253.9	348.9	80.1	5.1	14.2	28.0	29	
3.5	3.0 . . .	. . .	264.1	359.1	75.5	.810	30	121	58	
252	3 58	0.56	257.8	359.4	49.5	6.7	9.3	25.1	41	
3.0	1.7 Ra	. . .	249.4	351.0	53.7	.575	30	275	322	
253	4 04	0.25	170.5	273.8	57.9	7.2	20.8	82.1	54	
0.0	—2.3 . . .	. . .	174.2	277.5	51.0	.390	30	197	206	
254	4 20	. . .	216.6	323.8	64.8	5.0	(36.5)	106.9	80	
2.5	1.1 . . .	0.1	218.1	325.3	59.8	.560	29	162	156	
255	4 29	0.95	211.3	320.8	52.8	7.1	6.2	26.0	34	
4.0	1.5 Ra	. . .	200.1	309.6	51.0	.370	28	255	309	
				Nov. 4/5, 1935						
256	2 28	. . .	114.6	194.7	72.5	7.8	(32.4)	68.8	41	tr.2^s
—0.5	—1.2 . . .	0.2	141.3	221.4	74.6	.735	28	171	165	
257	2 36	. . .	223.7	306.0	71.0	8.3	(43.7)	118.1	94	
4.5	3.4 . . .	0.15	216.1	298.4	63.2	.625	30	212	222	
258	2 44	0.12	197.7	281.9	87.9	7.0	45.4	94.3	72	
3.5	3.0 . . .	. . .	199.4	283.6	80.9	.800	29	211	224	
259	3 16	. . .	146.8	239.1	84.1	3.4	(24.8)	53.2	67	
4.0	3.4 Ra	0.1	135.3	227.6	81.0	.790	29	286	311	
260	3 33	0.20	227.6	324.0	74.1	5.6	23.3	56.1	29	
3.0	2.1 . . .	. . .	222.6	319.0	68.7	.690	30	195	211	
261	3 35	. . .	140.1	237.0	80.9	6.3	(18.1)	38.3	53	
2.5	1.8 Ra	0.3	128.9	225.8	75.0	.760	29	285	317	
262	3 54	. . .	327.8	69.5	83.9	6.0	(43.8)	83.2	56	
3.0	2.7 . . .	0.1	281.4	23.1	81.7	.875	29	164	156	
263	3 58	. . .	162.5	265.2	66.4	6.1	(25.3)	76.9	47	
3.0	1.5 . . .	0.2	170.9	273.6	61.5	.540	30	183	185	
264	4 02	0.35	278.9	22.6	59.8	11.6	26.5	57.9	36	tr.1^s
—0.5	—1.3 . . .	. . .	257.5	1.2	56.7	.715	30	211	236	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
			Nov. 17/18, 1935							
265	21^h10^m	$0^s.45$	$27^0.4$	$40^0.8$	$84^0.8$	$7^0.1$	11.8	19.6	36	
—1.0	—1.3 . . .	. . .	$262^0.3$	$275^0.7$	$87^0.7$	.870	29	273^0	327^0	
266	21 34	0.13	204.0	223.4	67.0	2.4	14.3	39.8	66	
3.0	1.7 . . .	. . .	200.1	219.5	65.2	.580	29	325	340	
267	21 54	0.23	281.9	306.5	64.8	7.4	26.1	55.5	52	
3.5	2.9 . . .	. . .	271.4	296.0	59.2	.780	29	248	279	
268	22 10	0.14	148.4	176.8	63.7	5.1	30.5	89.6	71	
3.5	2.1 . . .	. . .	159.8	188.2	64.9	.565	25	215	227	
			Nov. 18/19, 1935							
269	19 49	. . .	247.6	241.9	88.0	7.0	(16.1)	31.7	49	tr.1s
3.0	2.5 . . .	0.4	230.3	224.6	81.0	.815	29	288	322	
270	20 00	. . .	200.1	197.1	69.0	10.7	(7.1)	17.7	40	
4.0	2.8 . . .	1.5	170.0	167.0	69.0	.615	26	50	20	
271	20 54	. . .	173.4	183.9	67.5	7.0	(16.1)	48.9	67	
3.5	2.0 . . .	0.4	175.9	186.4	60.6	.540	24	310	326	
272	21 52	0.35	314.3	339.2	77.4	5.2	10.8	18.4	44	
2.0	1.7 . . .	. . .	293.8	318.7	81.0	.890	30	310	341	
			Nov. 19/20, 1935							
273	21 34	0.55	239.1	260.5	64.8	8.3	12.6	33.6	46	
3.5	2.3 . . .	. . .	231.8	253.2	57.3	.600	30	274	314	
274	22 22	0.45	274.1	307.6	82.4	23.7	39.9	77.4	47	
1.5	1.1 . . .	. . .	293.0	326.5	59.2	.845	30	178	177	
275	22 51	0.23	137.7	178.3	67.6	7.6	26.5	71.2	60	
2.5	1.3 . . .	. . .	156.6	197.2	65.8	.610	26	235	256	
276	22 58	. . .	270.1	312.5	68.5	7.7	(32.0)	69.3	40	
4.5	3.9 . . .	0.2	275.6	318.0	61.2	.780	29	178	177	
			Nov. 21/22, 1935							
277	20 19	. . .	241.1	245.7	44.3	4.2	(9.7)	38.2	28	
3.2	0.9 . . .	0.4	244.0	248.6	40.7	.400	30	226	277	
278	21 09	0.85	196.3	213.6	65.3	11.5	11.2	36.4	39	
3.5	1.8 . . .	. . .	207.7	225.0	55.2	.495	27	255	297	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
			Feb. 17/18, 1936						
279	21^{h}48^m	...	171°.4	285°.0	57°.3	6°.8	(8.5)	34.9	52
2.5	0.1 ...	0^s.8	177°.1	290°.7	51°.4	.385	30	286°	320°
280	22 29	0.50	187.0	311.0	68.0	11.5	19.1	61.5	70
3.0	1.4 ...	...	194.3	318.0	57.0	.510	29	273	298
			Aug. 10/11, 1936						
281	22 52	...	259.3	201.5	66.6	4.2	(9.7)	20.8	42
3.0	2.2 ...	0.4	248.9	191.1	66.2	.720	30	292	333
282	22 59	0.15	230.6	174.5	69.9	6.0	31.0	78.0	55
4.0	3.0 P	...	233 9	177.8	64.0	.660	30	211	226
283	23 40	...	218.6	172.8	69.5	2.7	(11.1)	26.8	48
2.5	1.4 ...	0.2	211.6	165.8	68.4	.640	30	297	330
284	23 53	0.17	245.0	202.4	52.6	4.8	20.5	64.6	36
3.5	1.9 P	...	246.6	204.0	47.9	.520	29	188	194
			Aug. 11/12, 1936						
285	22 54	0.21	50.1	353.8	86.4	5.0	19.9	36.7	15
2.5	2.2 ...	...	14.5	289.2	84.0	.885	29	159	112
286	23 00	...	284.4	229.5	50.3	3.1	(22.6)	52.1	30
3.0	2.2 P	0.1	282.2	227.3	47.6	.720	28	208	234
287	23 03	0.30	271.3	217.1	71.0	7.8	21.6	44.3	14
2.0	1.4 P	...	276.5	222.3	63.3	.795	30	176	167
288	23 07	0.26	202.9	149.7	69.2	4.2	12.5	32.7	15
3.0	1.8 P	...	210.1	156.9	66.0	.605	30	206	271
289	23 09	0.30	167.4	114.9	82.5	5.8	16.1	33.3	8
3.0	2.4 P	...	207.7	155.2	81.0	.775	29	192	244
290	23 11	...	288.3	236.3	63.3	6.1	(25.3)	51.5	23
3.5	3.0 P	0.2	287.8	235.8	57.2	.815	29	176	171
291	23 13	0.33	250.0	198.5	48.9	4.5	11.1	34.6	6
3.0	1.3 P	...	252.5	201.0	44.7	.505	29	184	204
292	23 19	...	148.0	97.8	63.2	2.5	(10.4)	28.4	12
1.5	0.1 P	0.2	153.5	103.3	63.2	.555	26	204	270

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Aug. 11/12, 1936					
293	23^h21^m	...	264°.6	214°.9	51°.9	14°.3	(17.9)	48.7	22
2.0	0.7 P	$0^s.8$	272°.0	222°.3	38°.6	.590	28	170°	158°
294	23 28	0.32	149.8	101.8	77.9	3.6	8.6	18.5	35
3.5	2.7 ...	...	153.3	105.3	74.4	.715	27	282	330
295	23 30	0.30	242.1	194.7	64.4	8.5	23.5	60.1	31
2.0	0.9 P	...	248.1	200.7	56.4	.630	30	187	194
296	23 31	...	240.5	193.4	48.2	3.1	(8.9)	32.1	3
4.0	2.0 P	0.3	242.5	195.4	45.4	.440	29	182	200
297	23 45	0.38	280.9	237.3	72.0	7.3	15.4	27.7	18
1.0	0.6 ...	...	289.8	246.2	65.4	.845	30	145	66
298	23 47	0.20	183.8	140.7	84.0	4.9	20.4	41.5	13
2.0	1.4 P	...	223.8	180.7	82.4	.790	29	172	154
299	0 03	0.17	188.1	149.1	72.5	4.2	20.9	54.4	44
3.0	1.9 ...	...	190.9	150.9	68.3	.630	30	235	267
300	0 06	...	167.6	129.2	66.6	4.4	(12.6)	36.2	27
2.5	1.0 ...	0.3	173.7	135.3	63.1	.550	29	228	281
301	0 07	...	221.2	183.2	54.9	6.5	(10.8)	39.7	10
4.0	2.0 P	0.6	226.1	188.1	49.1	.440	30	186	204
302	0 09	...	234.4	196.8	80.3	4.3	(22.2)	47.0	18
3.5	2.9 P	0.15	242.0	204.4	76.3	.780	30	187	197
303	0 13	0.36	164.2	127.5	73.6	5.6	12.9	29.2	1
0.0	—1.0 ...	...	182.3	145.6	72.0	.660	29	182	270
304	0 14	...	192.4	156.0	57.6	7.2	(13.8)	55.2	29
1.0	—1.3 P	0.5	199.2	162.8	51.6	.390	30	201	222
305	0 18	0.30	258.7	233.3	63.7	6.7	18.6	44.6	16
3.5	2.6 P	...	259.2	223.8	57.0	.690	29	181	183
306	0 25	...	123.0	89.5	80.3	5.9	(11.3)	21.9	8
3.0	2.4 ...	0.5	156.4	122.9	84.4	.795	28	169	28
307	0 31	0.15	232.1	200.0	63.9	2.6	14.8	39.6	11
4.0	2.8 P	...	233.6	201.5	61.4	.610	30	190	214

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Aug. 11/12, 1936						
308	0^h43^m	...	295°.4	266°.3	73°.5	14°.0	(58.1)	110.1	82	
1.0	0.6 P	0s.2	288°.6	259°.5	60°.2	.850	30	163°	157°	
309	0 51	...	269.9	242.8	55.0	6.9	(11.5)	27.6	31	
3.5	2.5 ...	0.6	258.7	231.6	53.0	.655	28	249	305	
310	0 55	0.37	137.8	111.8	69.7	4.9	10.4	24.6	22	
1.5	0.4 ...	...	148.1	122.1	66.6	.640	28	229	304	
311	1 06	...	303.7	280.4	79.8	5.6	(23.2)	41.4	19	tr.
0.0	—0.3 ...	0.2	295.4	272.1	74.5	.885	30	155	115	
312	1 09	0.18	262.5	239.8	50.7	5.4	34.6	98.1	71	
3.5	2.2 P	....	262.1	239.4	45.3	.585	28	168	163	
313	1 18	...	223.4	203.0	57.8	7.3	(16.7)	55.2	28	
—0.5	—2.4 P	0.4	224.6	204.2	50.5	.465	29	193	208	
314	1 19	...	283.9	263.8	75.8	4.4	(18.3)	35.4	5	
4.0	3.6 ...	0.2	277.1	257.0	71.8	.845	30	181	185	
				Sep. 18/19, 1936 (New orientation of reticle)						
315	23 05	...	335.0	318.8	+2.8	6.1	(17.5)	59.9	37	
3.5	1.7 ...	0.3	330.5	314.3	—1.3	.480	24	168	160	
				Sep. 20/21, 1936						
316	1 20	...	355.0	14.7	+25.9	3.9	(9.0)	16.3	30	
3.5	3.1 ...	0.4	353.4	13.1	+29.5	.855	27	262	328	
317	2 32	0.32	345.6	23.2	—3.8	4.5	10.8	39.9	13	
3.5	1.5 ...	...	341.3	18.9	—5.3	.435	28	187	202	
318	2 39	0.64	324.1	3.5	+39.9	21.6	28.0	61.9	45	
3.5	2.8 ...	...	312.9	352.3	+20.5	.750	29	137	111	
319	2 48	—	315.2	356.8	+29.4	6.4	—	—	—	*)
—	—	—	309.1	350.7	+26.0	.705	—	—	—	
320	3 06	0.40	358.1	44.2	+3.2	8.9	18.5	56.7	35	
2.5	1.0 ...	...	350.2	36.3	—0.8	.535	23	182	184	

*) Only train seen.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Nov. 19/20, 1936						
321	2^h43^m	...	333°.6	73°.2	+6°.0	6°.2	(5.2)	14.6	31	
1.5	—0.1 ...	$1^s.2$	333°.9	73°.5	—0°.2	.515	29	96°	28°	
322	3 32	0.24	325.4	77.1	+16.9	10.2	35.6	94.7	67	tr.$0^s.5$
1.5	0.3 L	...	315.5	67.2	+13.2	.605	29	168	162	
323	3 35	0.16	332.5	84.6	+19.8	4.1	26.6	63.7	38	
4.0	3.2 L	...	328.1	80.5	+18.5	.705	27	166	155	
324	3 55	...	355.1	112.5	+5.7	5.9	24.5	68.1	49	
2.5	1.2 L	0.2	349.4	106.8	+4.2	.590	19	178	177	
				Nov. 21/22, 1936						
325	3 19	...	358.7	109.2	+27.4	5.8	(24.1)	49.1	50	
4.0	3.5 ...	0.2	356.8	107.3	+21.9	.825	24	102	75	
326	4 17	0.11	306.0	70.9	16.3	2.6	19.6	62.5	37	
3.0	1.4 ...	...	303.7	68.6	15.0	.515	29	158	140	
327	4 48	...	349.1	121.9	+0.9	4.7	(15.6)	51.2	54	
3.5	1.8 ...	0.25	351.3	124.1	—3.2	.500	15	86	70	
328	4 52	...	299.8	73.6	+33.0	6.8	(13.1)	30.2	55	
2.8	1.9 ...	0.5	306.5	80.3	+29.3	.685	28	35	18	
				Feb. 9/10, 1937						
329	22 14	0.30	318.6	71.8	21.1	5.2	14.4	36.3	25	
3.5	2.4 ...	...	313.3	66.5	19.7	.645	11	166	161	
				March 2/3, 1937						
330	22 00	...	355.7	125.8	+16.5	6.9	(2.3)	4.7	28	*)
0.0	—0.9 ...	3.0	358.3	128.4	+10.1	.700	24	50	7	
				March 3/4, 1937						
331	23 28	...	323.7	116.9	24.6	5.5	(29.0)	67.7	52	
3.8	3.0 ...	0.15	318.1	111.3	22.5	.710	19	152	143	
332	23 41	...	348.1	144.6	+15.1	9.0	(6.0)	13.8	41	
4.0	3.1 ...	1.5	353.9	150.4	+8.1	.675	28	31	10	

*) No train visible.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				April 6/7, 1937						
333	22^h43^m	$0^s.90$	$316^0.4$	$132^0.0$	$+13^0.9$	$6^0.4$	5.9	16.5	27	
3.5	2.0 . . .	. . .	$318^0.6$	$134^0.2$	$+7^0.9$	.540	13	42^0	24^0	
334	22 47	0.40	316.6	133.2	+36.2	9.6	20.0	41.7	32	
3.0	2.4 . . .	. . .	304.7	121.3	+35.9	.780	12	204	212	
				Aug. 9/10, 1937						
335	23 08	. . .	336.1	281.0	+10.5	9.8	(71.5)	211.2	196	
3.0	1.6 P	0.1	333.2	278.0	+1.1	.555	25	131	126	
336	23 21	0.14	347.1	295.4	+23.9	3.7	22.0	45.7	37	
3.5	3.0 . . .	. . .	343.5	291.8	+25.6	.810	29	233	272	
337	23 28	0.23	331.8	281.8	+20.0	4.5	15.0	34.2	21	
2.0	1.1 P	. . .	330.3	280.0	+15.8	.695	27	141	88	
338	23 39	. . .	316.5	269.3	+27.3	7.0	(23.2)	55.3	46	
4.0	3.2 . . .	0.25	308.7	261.5	+28.8	.710	26	236	264	
339	23 56	<0.05	314.1	271.2	+8.1	10.4	129.0	510.0	506	*)
3.5	1.3 . . .	<0.05	316.7	273.8	—2.0	.415	23	101	98	
340	0 15	. . .	317.5	279.2	+16.4	6.6	(18.9)	54.4	48	
3.0	1.6 . . .	0.3	317.5	279.2	+9.9	.570	26	118	89	
341	0 18	0.27	339.4	302.0	+15.8	6.0	17.7	43.4	25	
2.5	1.5 P	. . .	335.6	298.2	+11.1	.665	29	148	108	
342	0 22	. . .	318.2	281.7	+24.6	6.0	(31.6)	78.4	58	
4.0	3.0 P	0.15	315.5	279.0	+19.2	.670	27	146	131	
343	1 06	0.22	322.4	296.8	+15.8	6.4	23.5	62.7	48	
0.0	—1.3 P	. . .	320.0	294.4	+9.8	.585	29	133	107	
344	1 13	0.40	358.4	334.7	+6.5	6.0	12.5	33.2	24	
1.0	—0.3 P	. . .	355.6	331.9	+1.2	.575	28	135	78	
				Sep. 29/30, 1937						
345	21 46	0.08	338.1	312.7	16.2	3.3	34.3	81.2	83	
3.8	2.9 . . .	0.05	340.5	315.1	13.9	.700	23	90	74	

*) Perfectly straight; looks like a real meteor exept for the enormous apparent velocity; well observed.

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_o m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	I Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Sep. 29/30, 1937						
346	22^h02^m	$0^s.19$	312°.9	291°.6	24°.9	7°.9	34.5	88.9	68	
1.8	0.7 . . .	. . .	309°.6	288°.3	17°.6	.625	21	186°	188°	
347	22 16	0.14	337.3	319.7	+10.4	3.0	15.1	40.4	38	
3.5	2.3 . . .	. . .	338.1	320.5	+7.5	.610	24	112	76	
348	23 01	0.41	319.4	313.0	+10.6	7.3	14.1	45.0	24	tr.1s
1.5	—0.2 . . .	. . .	314.2	307.8	+5.4	.495	21	179	178	
				Sep. 30/Oct. 1, 1937						
349	23 02	0.33	339.9	334.5	+10.3	3.4	7.3	18.2	8	
4.0	2.8 . . .	. . .	336.8	331.4	+8.8	.620	26	186	346	
350	23 59	0.75	325.7	334.7	+25.5	10.4	11.1	22.8	26	
3.0	2.3 . . .	. . .	314.5	323.5	+28.7	.750	28	239	310	
				Oct. 5/6, 1937						
351	22 43	. . .	330.9	325.8	+37.4	6.8	(35.8)	66.0	45	
—0.5	—0.9 . . .	0.15	323.0	317.9	+35.2	.865	28	214	234	
352	23 11	. . .	331.6	333.4	+17.7	13.8	(57.3)	150.6	130	
0.5	—0.7 . . .	0.2	326.8	328.6	+4.7	.605	25	147	141	
353	23 44	. . .	352.4	2.7	+8.5	6.4	(46.7)	124.0	96	
4.0	2.9 . . .	0.1	346.1	356.4	+7.0	.625	29	191	194	
				Oct. 6/7, 1937						
354	22 03	0.73	328.6	314.6	+1.0	4.9	5.6	19.7	6	
4.0	2.0 . . .	. . .	324.3	310.3	—1.3	.435	17	195	246	
355	22 29	0.10	344.5	336.9	+17.3	7.8	64.9	151.7	129	
3.5	2.7 . . .	. . .	336.8	329.2	+15.3	.710	26	204	209	
356	23 15	0.52	339.0	342.8	+5.9	9.5	14.1	44.7	50	
3.0	1.4 . . .	. . .	342.4	346.2	—2.9	.515	26	96	64	
357	23 35	0.53	332.9	341.7	+14.1	8.4	12.3	31.1	9	
3.0	1.9 . . .	. . .	324.8	333.6	+11.3	.625	26	196	246	
				Oct. 7/8, 1937						
358	22 58	. . .	350.0	350.6	+2.4	5.9	(31.0)	96.7	83	
1.0	—0.6 . . .	0.15	348.8	349.4	—3.4	.510	27	127	112	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Oct. 7/8, 1937						
359	23^h24^m	...	306°.2	313°.4	18°.9	6°.6	(12.7)	39.3	27	
4.5	3.0 ...	$0^s.5$	299°.5	306°.7	17°.1	.535	22	222°	254°	
360	0 04	0.24	331.6	348.8	+25.8	11.0	34.0	74.0	56	tr.1s
—1.0	—1.8 ...	...	328.8	345.5	+15.1	.715	28	139	120	
				Oct. 30/31, 1937						
361	21 44	...	353.1	357.9	—6.8	7.7	(7.7)	32.4	14	
3.5	1.1 Ra	1.0	346.3	351.1	—10.5	.375	20	168	148	
362	22 00	0.37	310.9	319.8	32.2	7.4	15.4	34.3	38	
2.0	1.2 Ra	...	302.2	311.1	31.6	.710	23	260	297	
363	23 25	0.84	322.5	352.6	+37.1	16.0	15.6	29.5	26	
—1.0	—1.6 Ra	...	303.0	333.1	+37.1	.790	26	235	290	
				Oct. 31/Nov. 1, 1937						
364	22 26	1.03	310.9	327.2	+25.1	10.0	8.1	19.8	22	
2.5	1.4 Ra	...	300.0	316.3	+23.6	.625	20	248	304	
365	22 28	0.38	343.9	0.3	+16.0	7.6	16.2	38.3	18	
4.0	3.1 Ra	...	336.3	352.7	+14.2	.700	24	201	230	
366	22 36	0.13	306.4	325.2	+15.9	3.1	17.2	56.6	44	
3.8	2.1 ...	...	303.6	322.4	+14.2	.505	17	218	232	
367	23 30	...	355.4	27.6	—0.9	9.5	(21.9)	79.9	56	
3.0	1.0 Ra	0.4	348.3	20.5	—7.3	.450	28	156	144	
368	23 40	0.95	307.0	341.8	+18.2	9.5	8.3	24.1	12	
0.0	—1.7 Ra	...	298.0	332.8	+14.2	.505	20	208	261	
				Dec. 7/8, 1937						
369	22 02	1.04	322.6	9.3	+29.0	13.0	10.4	21.6	22	
2.3	1.5 ...	...	307.7	354.4	+28.9	.730	18	249	296	
370	22 11	0.13	332.6	21.6	+19.6	3.7	19.5	44.3	26	
1.5	0.7 G	...	329.1	18.1	+18.0	.705	19	188	193	
371	22 32	0.33	2.7	56.9	+22.0	10.1	24.4	54.4	55	
2.8	2.1 ...	...	2.7	56.9	+11.9	.745	28	102	72	

Table IV. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t_0 m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Feb. 7/8, 1938						
372	3^h17^m	$0^s.42$	299°.0	125°.6	+15°.9	5°.1	9.5	33.3	52	
3.0	1.0 . . .	. . .	299°.6	126°.2	+10°.8	.450	29	68°	37°	
373	3 26	0.16	325.0	154.0	+5.9	4.6	26.8	88.9	68	
3.5	1.8 . . .	. . .	320.6	149.6	+4.4	.495	29	142	127	
374	4 06	0.31	329.8	168.6	+15.6	6.6	16.6	39.2	13	
2.0	1.0 . . .	. . .	324:3	163.1	+19.6	.670	27	189	208	
375	5 05	1.72	315.1	204.7	+8.8	10.9	5.3	14.3	27	
4.5	3.2 . . .	. . .	356.4	210.0	—0.7	.575	13	9	5	
				March 24/25, 1938						
376	0 52	. . .	334.3	169.1	+17.9	4.7	(34.3)	85.9	88	
4.5	3.6 . . .	0.1	332.5	167.3	+13.5	.675	28	92	74	
				March 30/31, 1938						
377	1 53	0.73	325.0	180.9	—1.0	5.3	5.7	20.2	11	
3.5	1.4 . . .	. . .	320.8	176.7	+2.2	.430	29	194	334	
378	2 43	0.43	312.1	180.5	+9.4	6.4	11.7	38.9	64	
0.0	—1.9 . . .	. . .	315.5	183.9	+3.9	.460	29	36	21	
				April 28/29, 1938						
379	0 35	0.24	315.0	180.0	+24.9	4.5	14.5	34.7	15	
4.0	3.1 . . .	. . .	310.2	175.2	+25.7	.680	21	189	202	
380	1 43	. . .	306.2	188.2	+29.4	3.0	(12.4)	27.9	28	tr.$0^s.5$
0.0	—1.0 . . .	0.2	304.7	186.7	+26.7	.670	24	114	63	

Table V.
Meteor Velocities Observed in Arizona, 1931.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 6/7, 1931					
1	21h47m	0s.25	328°.4	303°.6	70°.3	4°.0	16.8	23.0	41
3.0	2.4 ...	...	321°.0	296°.2	71°.0	.756	30	281°	327°
2	22 46	0.05	321.1	311.1	64.8	3.9	37.2	54.0	82
3.5	3.0 ...	...	322.2	312.1	66.8	.808	30	340	348
3	22 48	0.18	316.1	306.5	75.2	8.0	49.1	72.8	81
3.0	2.0 ...	...	300.6	291.0	76.0	.659	30	275	297
4	22 54	0.05	0.1	352.0	81.1	8.7	174.0	262.5	242
3.8	2.9 ...	...	334.3	326.2	80.9	.690	29	220	225
5	23 19	0.18	341.3	339.5	67.6	2.9	20.2	28.0	36
3.5	3.0 ...	...	338.1	336.3	68.6	.809	30	257	311
6	0 31	0.14	341.8	358.0	80.7	3.8	33.4	48.5	52
3.2	2.3 ...	...	336.8	353.0	82.1	.672	28	260	292
7	0 38	0.08	338.6	356.5	64.8	3.0	36.1	52.4	62
4.0	3.6 ...	...	337.5	355.4	65.1	.832	29	275	303
8	1 50	0.34	331.8	7.7	59.0	4.3	11.1	15.1	30
3.0	2.6 ...	...	329.4	5.3	61.1	.843	29	258	330
				Oct. 7/8, 1931					
9	23 43	0.14	327.8	333.0	76.1	7.2	54.2	81.0	99
4.0	3.4 ...	...	342.2	347.4	74.8	.765	29	58	44
10	23 54	0.60	47.9	55.8	71.5	15.0	32.5	46.5	27
2.5	1.7 ...	...	32.8	40.7	77.4	.720	27	209	239
11	0 17	...	338.1	351.7	77.2	21.2	22.5	31.7	20
3.0	2.0 ...	...	295.9	309.5	75.3	.650	30	217	285
12	0 20	0.07	269.2	283.6	71.3	4.9	78.2	118.0	118
3.8	2.2 A	...	263.1	277.5	70.4	.507	30	262	277
13	0 27	...	19.8	36.0	83.4	17.7	6.8	9.2	28
1.0	—0.4 A	...	163.8	180.0	88.0	.555	28	257	341
14	0 34	0.30	14.0	31.9	63.3	8.0	29.7	42.5	66
3.0	2.6 ...	...	21.0	38.9	65.4	.844	27	323	337

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ωz deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 7/8, 1931					
15	1^h07^m	$0^s.25$	311°.2	337°.4	70°.3	6°.0	21.8	30.3	34
3.5	2.6 . . .	. . .	301°.6	327°.8	71°.3	.680	30	248°	304°
16	3 00	0.25	18.7	73.1	84.0	3.2	17.0	23.2	10
3.0	2.0 . . .	. . .	12.3	66.7	85.2	.640	27	202	301
				Oct. 8/9, 1931					
17	20 27	0.23	42.8	0.	85.1	3.2	16.0	21.9	38
3.2	2.1 A	. . .	40.8	358.	86.4	.625	28	278	325
18	20 48	0.24	60.6	23.	85.5	3.2	17.2	23.5	38
3.3	2.1 A	. . .	67.6	30.	86.8	.595	28	275	322
19	21 19	>0.40	254.5	224.7	82.1	12.0	22.0	30.6	8
3.0	1.7 . . .	. . .	276.0	246.2	77.4	.572	29	193	260
20	22 54	0.13	16.5	10.4	79.3	3.8	35.4	51.2	76
3.5	2.7 . . .	. . .	21.7	15.6	81.0	.697	28	320	334
21	23 08	0.30	112.6	110.	87.4	2.8	15.8	21.6	30
4.0	2.6 . . .	. . .	145.1	142.5	87.3	.550	28	251	316
22	23 17	0.24	50.1	49.7	65.8	10.6	51.2	76.0	55
3.0	2.4 . . .	. . .	41.1	40.7	68.8	.762	27	210	225
23	1 21	0.15	339.9	10.5	72.0	4.0	31.2	44.6	16
3.3	2.8 . . .	. . .	335.0	5.6	70.9	.792	29	177	172
24	1 43	0.32	272.8	309.	83.2	5.3	26.9	37.8	14
3.5	2.2 . . .	. . .	273.2	309.	80.2	.570	29	160	119
25	1 49	0.24	289.4	327.0	69.1	3.5	16.8	23.0	40
3.3	2.2 A	. . .	285.3	322.9	70.1	.615	30	278	325
26	2 00	0.23	46.1	86.5	68.1	3.0	15.8	21.6	25
3.5	2.8 . . .	. . .	48.3	88.7	69.2	.730	23	247	307
27	2 46	0.24	27.1	79.0	76.3	7.2	30.9	44.4	52
3.5	2.7 A	. . .	39.5	91.4	77.7	.698	25	273	302
28	3 52	0.23	338.4	46.8	64.3	3.0	11.9	16.2	25
3.2	2.8 . . .	. . .	338.1	46.5	65.8	.835	26	249	323

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur, est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 8/9, 1931					
29	3 55	...	356°.8	66°.0	83°.2	12°.7	19.8	27.5	24
3.0	2.1...	...	319°.5	28.7	80°.0	.678	28	128°	62°
30	4 20	0.43	0.3	75.7	74.7	12.5	31.7	45.5	32
3.0	2.4...	...	337.9	53.3	74.1	.760	26	136	102
31	4 32	0.12	19.6	98.0	75.0	8.2	66.7	100.0	76
2.5	1.7...	...	15.5	93.9	78.8	.718	25	185	187
32	4 48	0.20	302.2	24.6	77.3	11.4	97.2	146.5	118
0.5	—0.7...	...	281.2	3.6	75.2	.600	29	166	163
				Oct. 9/10, 1931					
33	20 19	0.33	342.8	299.	83.1	6.0	22.8	33.5	36
3.2	2.2...	...	323.2	279.4	82.0	.658	29	251	300
34	20 51	0.09	353.0	317.2	78.0	3.0	30.0	43.0	71
4.0	3.2...	...	353.7	317.9	79.4	.720	29	343	350
35	21 11	0.40	59.2	28.4	77.7	8.0	26.4	37.1	55
2.5	1.4...	...	69.2	38.4	81.2	.610	28	297	323
36	21 15	0.22	304.7	274.9	65.3	4.0	20.1	28.0	40
3.5	2.7...	...	301.9	272.1	65.0	.697	30	267	315
37	22 09	0.05	303.4	287.0	82.1	4.0	84.4	127.2	155
3.0	2.0...	...	306.3	289.0	84.3	.640	29	15	12
38	22 13	0.43	283.8	268.4	77.5	10.9	31.8	45.5	48
3.5	2.1...	...	269.4	254.0	73.9	.548	30	257	294
39	23 16	0.25	349.0	349.4	70.7	4.0	23.2	32.7	43
3.5	3.0...	...	344.4	344.8	72.2	.798	29	266	310
40	2 14	0.12	336.3	21.2	70.5	2.0	13.6	18.6	36
2.0	1.4...	...	335.4	20.3	70.9	.785	28	277	329
41	2 34	...	57.5	107.4	62.1	16.0	17.4	23.8	28
—1.0	—2.1...	...	73.3	123.2	63.2	.620	21	256	304
42	2 47	0.48	284.1	337.3	52.4	4.6	17.0	23.2	34
3.0	1.6...	...	279.6	332.8	53.2	.540	30	259	318

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 9/10, 1931					
43	3 08	0.45	19°.3	77°.7	57°.0	9°.7	17.9	24.8	32
1.0	0.7 . . .	. . .	25°.8	84°.2	59°.0	.860	20	270°	309°
44	3 25	0.23	1.2	63.8	71.6	10.6	41.7	61.0	37
3.0	2.4 . . .	. . .	351.2	53.8	74.6	.760	26	194	204
45	4 08	0.30	54.4	127.8	65.6	9.5	45.7	67.4	57
1.5	0.5 . . .	. . .	65.8	139.2	66.3	.650	22	233	251
				Oct. 10/11, 1931					
46	20 47	0.10	317.3	281.3	70.1	4.0	48.1	71.0	86
4.0	3.3 . . .	. . .	312.6	276.5	70.0	.740	30	289	309
47	22 06	0.08	346.6	330.2	84.2	3.3	44.8	66.1	83
4.0	3.1 . . .	. . .	357.5	341.1	84.0	.670	28	63	45
48	22 56	0.24	319.6	315.7	75.4	3.7	15.2	20.8	44
3.0	2.2 . . .	. . .	311.7	307.8	77.3	.710	30	303	337
49	23 03	0.14	5.2	3.1	74.3	2.8	27.0	38.0	41
4.0	3.4 . . .	. . .	1.7	359.6	75.4	.770	29	253	296
50	23 09	0.33	306.5	305.8	71.9	4.3	16.7	22.8	39
3.5	2.6 . . .	. . .	300.4	299.7	72.3	.672	30	275	324
51	23 16	0.33	314.5	315.6	64.3	13.7	45.2	66.7	38
0.0	—0.5 . . .	. . .	313.6	314.7	58.3	.790	30	169	161
52	1 12	0.05	353.8	23.9	69.2	2.1	19.2	26.7	38
4.5	4.0 . . .	. . .	353.0	23.1	70.4	.815	28	269	316
53	1 32	0.11	350.7	25.8	79.4	3.0	38.0	55.6	36
4.0	3.2 . . .	. . .	344.2	19.3	80.0	.707	28	215	241
54	1 58	0.20	204.6	246.2	75.8	4.8	57.6	86.2	59
3.0	0.5 . . .	. . .	203.5	245.1	73.7	.346	30	197	206
55	2 16	0.80	298.0	344.1	57.7	6.8	13.1	17.9	22
3.0	2.0 . . .	. . .	292.0	338.1	57.6	.650	30	229	323
56	2 24	0.44	86.0	134.1	74.1	11.8	45.0	66.2	47
3.8	2.6 . . .	. . .	77.9	126.0	78.0	.600	25	144	125

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 10/11, 1931					
57	2^h43^m	$0^s.23$	$333^0.0$	$25^0.9$	$83^0.8$	$6^0.0$	40.5	59.2	79
2.2	1.2 ...	...	$359^0.1$	$52^0.$	$85^0.5$	.640	28	307^0	323^0
58	3 13	0.45	206.0	266.3	82.3	6.0	21.7	30.1	38
3.0	1.1 ...	...	192.1	252.4	80.1	.434	29	259	308
59	3 23	0.12	292.8	355.7	88.4	3.3	41.8	61.0	58
3.5	2.2 ...	...	251.1	314.0	88.3	.560	28	228	250
60	3 23	0.30	155.3	217.2	85.3	8.9	52.4	77.6	51
2.0	0.3 ...	...	193.1	256.0	84.1	.489	29	158	148
61	3 38	0.18	348.9	55.5	70.1	8.5	45.8	67.5	51
3.2	2.7 ...	...	338.7	45.3	68.5	.814	26	136	116
62	4 37	0.14	207.9	289.2	78.4	5.8	95.7	144.0	123
3.8	1.7 ...	...	214.6	295.9	76.0	.402	30	141	133
				Oct. 11/12, 1931					
63	19 59	0.14	291.8	244.7	67.3	8.0	77.1	116.3	120
4.0	2.9 ...	...	284.6	237.5	65.3	.610	30	267	281
64	20 35	0.32	24.8	346.7	65.8	12.0	39.8	58.0	43
3.5	3.2 ...	...	11.2	333.1	65.3	.860	30	226	256
65	22 31	0.20	12.6	3.5	64.4	4.0	25.0	35.2	44
3.5	3.1 ...	...	10.6	1.5	66.2	.850	29	266	307
66	23 10	...	249.4	250.0	66.8	13.3	18.0	25.0	7
1.5	—0.6 ...	...	256.3	256.9	60.5	.401	30	190	320
67	1 17	0.12	338.3	10.6	60.6	4.0	34.9	50.6	22
2.8	2.5 ...	...	334.4	6.7	59.6	.872	30	173	164
68	1 49	0.11	272.5	312.8	68.9	3.0	43.8	64.6	91
4.0	2.7 ...	...	271.9	312.2	70.6	.560	30	324	335
69	1 56	0.05	271.3	313.4	78.0	5.0	139.0	210.0	184
4.0	2.7 ...	...	271.3	313.4	75.3	.560	30	154	150
70	1 58	0.13	237.1	279.7	74.1	5.1	72.2	108.5	117
3.5	1.4 ...	...	227.8	270.4	73.9	.410	30	278	293

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 11/12, 1931					
71	2^h28^m	$0^s.35$	273°.3	323°.4	57°.6	5°.0	25.8	36.3	38
3.5	1.9 ...	...	269°.9	320°.0	57°.5	.500	30	248°	287°
72	2 33	0.12	52.5	103.8	77.2	3.8	46.5	68.6	66
3.5	2.5 ...	...	59.9	111.2	77.5	.640	25	262	284
73	2 50	0.75	24.7	80.3	78.4	10.5	12.2	16.6	40
2.0	1.2 ...	...	41.6	97.3	75.3	.712	25	330	348
74	4 07	0.12	324.1	39.0	61.8	9.0	99.5	150.0	123
3.8	3.2 ...	...	314.4	29.3	62.7	.779	28	184	186
75	4 10	0.55	277.5	351.9	60.4	2.9	7.0	9.5	38
3.2	1.9 ...	...	279.1	354.7	60.4	.573	30	32	7
76	4 15	0.75	268.3	345.2	66.8	6.0	14.3	19.6	32
3.0	1.5 ...	...	273.4	350.3	63.9	.538	30	100	36
				Oct. 12/13, 1931					
77	20 03	0.12	101.4	56.3	82.1	3.2	48.0	71.0	95
3.2	1.7 ...	...	106.4	61.3	80.7	.528	27	30	22
78	21 48	1.5	58.8	39.9	81.0	9.5	11.3	15.4	21
1.0	0.0 ...	...	36.9	18.	84.3	.640	28	226	328
79	22 10	0.09	300.4	287.0	67.7	3.8	53.0	79.0	64
4.0	3.1 ...	...	297.6	284.2	66.9	.680	30	229	250
80	22 36	0.05	346.8	339.9	80.6	4.0	56.6	84.5	91
4.8	3.9 ...	...	340.8	333.9	82.3	.680	29	274	292
81	23 04	0.45	5.3	5.4	78.4	6.0	12.5	17.0	44
3.5	2.7 ...	...	20.8	20.9	78.4	.720	28	27	10
82	23 17	0.25	248.7	252.0	78.1	6.0	34.0	49.5	45
3.8	2.0 ...	...	246.5	249.8	75.1	.459	29	243	279
83	1 21	0.40	310.0	344.3	54.3	8.9	24.8	34.9	44
3.0	2.2 ...	...	303.4	337.7	56.1	.722	30	265	308
84	1 33	0.45	311.2	348.5	64.6	8.0	19.9	27.6	40
2.5	2.1 ...	...	304.9	342.2	66.8	.710	30	268	316

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 12/13, 1931					
85	2^h02^m	...	37°.3	81°.9	73°.8	10°.0	14.3	19.6	29
3.3	2.4 ...	...	48°.7	93°.3	77°.4	.679	29	251°	321°
86	2 18	0.70	183.4	232.	86.2	8.1	22.1	30.7	33
3.0	1.1 ...	...	177.9	226.5	82.2	.449	28	249	301
87	2 54	0.08	243.9	301.5	82.2	4.0	96.0	144.8	117
3.8	2.2 ...	...	239.9	297.5	80.4	.500	29	182	183
88	2 58	0.32	347.4	46.	83.6	6.0	23.3	32.8	44
4.0	2.9 ...	...	4.9	63.5	86.1	.630	27	273	312
89	3 24	0.11	348.8	53.9	71.0	4.7	48.2	71.4	48
1.0	0.4 ...	...	345.5	50.6	72.7	.783	26	198	209
90	3 35	0.22	16.7	84.6	72.3	10.1	44.2	65.2	59
1.8	1.1 ...	...	28.5	96.4	76.8	.727	25	244	266
91	4 04	0.24	324.4	39.5	76.0	2.7	14.1	19.3	16
3.0	2.2 ...	...	318.4	33.5	75.0	.715	27	143	43
92	4 42	0.52	20.7	105.3	76.9	6.0	14.4	19.7	14
3.5	2.7 ...	...	25.4	110.0	78.8	.700	25	215	309
				Oct. 13/14, 1931					
93	20 40	0.05	297.9	263.0	77.9	0.8	20.3	28.2	58
3.0	2.0 ...	...	299.7	264.8	78.0	.641	30	8	4
94	21 08	0.35	319.8	291.9	68.2	7.5	20.5	28.5	37
3.0	23 F	...	310.2	282.3	67.0	.737	30	258	311
95	22 13	0.64	338.9	327.2	75.2	5.9	10.9	14.8	36
3.5	2.7 F	...	327.4	315.7	77.0	.718	30	280	336
96	1 24	0.74	334.4	10.5	64.6	6.7	7.9	10.7	34
3.0	2.6 ...	...	341.7	17.8	64.1	.858	24	29	9
97	1 24	0.12	352.2	28.3	62.7	3.6	29.8	42.7	30
3.8	3.6 ...	...	350.4	26.5	61.3	.895	28	135	94
98	1 33	0.42	298.9	337.2	57.4	7.0	21.5	29.9	42
1.5	0.5 F	...	293.7	332.0	58.4	.655	30	269	315

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 13/14, 1931					
99	1^h52^m	$0^s.34$	58°.4	101°.5	75°.2	10°.5	35.2	51.0	48
3.0	1.8 F	...	78°.2	121°.3	77°.4	.594	25	250°	280°
100	3 05	0.10	332.3	33.6	66.3	3.7	42.0	61.4	55
4.0	3.6 ...	...	331.3	32.6	64.8	.830	27	116	90
101	3 28	0.13	213.6	280.7	77.5	6.0	128.0	193.0	163
3.8	1.5 ...	...	215.1	282.2	75.0	.370	30	180	180
102	3 49	0.54	348.7	61.0	87.6	8.0	20.8	28.9	48
4.5	3.3 B	...	73.6	145.9	82.0	.605	27	301	329
103	3 58	0.54	136.4	211.0	72.3	6.9	28.5	40.8	49
3.0	0.4 ...	...	135.4	210.0	69.2	.329	29	268	304
104	4 04	1.30	30.3	106.4	75.3	29.3	24.7	34.7	36
2.0	1.5 ...	...	343.6	59.7	69.4	.816	26	107	65
105	4 13	0.05	175.7	254.	84.9	2.2	81.0	122.0	96
4.0	2.4 ...	...	178.7	257.	84.1	.490	29	202	210
106	4 20	0.12	218.4	298.5	77.2	11.1	230.0	347.0	320
3.8	1.2 ...	...	215.2	295.3	71.9	.328	30	189	190
107	4 24	0.10	327.2	48.3	65.2	6.0	68.2	102.8	79
2.3	1.7 ...	...	320.6	41.7	67.1	.781	27	206	215
108	4 28	0.05	28.2	110.3	81.7	2.9	48.0	71.0	47
3.0	2.1 ...	...	23.9	106.	82.6	.676	26	163	155
109	4 30	0.06	71.3	153.9	65.8	3.7	70.6	106.0	87
3.0	1.9 ...	...	73.6	156.2	67.4	.630	24	143	134
110	4 42	0.05	332.9	58.5	72.3	6.9	118.5	178.8	154
3.5	2.8 ...	...	324.1	49.7	74.2	.740	26	193	196
				Oct. 14/15, 1931					
111	22 42	0.12	319.5	316.1	72.7	4.6	44.4	65.4	56
2.3	1.5 ...	...	313.4	310.0	72.3	.714	30	238	265
112	1 28	0.50	77.6	115.7	62.4	9.0	31.5	45.2	40
1.2	—0.3 ...	...	84.9	123.0	63.6	.537	20	241	267

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 14/15, 1931					
113	2^h09^m	$0^s.34$	$334^0.7$	$23^0.0$	$52^0.7$	$5^0.0$	13.5	18.4	32
3.2	2.8 ...	...	$332^0.2$	$20^0.5$	$54^0.3$	.894	29	259^0	324^0
114	2 38	0.23	18.9	74.5	71.9	6.8	29.3	42.0	66
4.0	3.5 ...	...	28.3	83.9	69.5	.795	24	353	356
115	2 42	0.05	359.1	55.7	63.2	2.0	54.8	81.7	67
4.0	3.7 ...	...	359.0	55.6	64.1	.877	26	229	246
116	2 55	0.15	63.4	123.3	63.1	7.7	76.6	115.3	108
0.5	—0.6 ...	...	71.3	131.2	63.6	.629	21	245	255
117	3 08	0.05	320.5	23.6	66.1	2.6	42.7	63.0	66
2.0	1.4 ...	...	318.8	21.9	67.4	.760	28	261	287
118	3 24	0.17	52.1	119.2	76.4	3.8	31.4	45.2	53
4.0	3.0 ...	...	59.2	126.3	76.1	.660	25	273	301
119	3 46	0.10	43.6	116.2	78.1	6.0	87.3	131.5	106
3.5	2.5 ...	...	43.7	116.3	80.7	.661	26	176	176
120	3 49	0.03	25.2	98.5	73.5	2.5	100	150.8	126
2.5	1.8 ...	...	23.9	97.2	75.1	.752	25	191	193
121	3 56	0.10	275.5	350.6	66.9	4.0	62.7	94.0	66
3.2	1.7 ...	...	270.2	345.3	65.9	.538	30	195	202
122	4 00	1.20	333.9	50.0	55.8	13.8	15.1	20.7	42
0.8	0.6 ...	...	344.7	60.8	58.9	.900	26	306	336
				Oct. 16/17, 1931					
123	23 22	0.10	331.3	339.9	55.9	2.0	19.7	27.3	48
2.3	2.0 ...	...	329.8	338.4	56.4	.875	30	294	329
124	23 36	0.25	302.9	315.0	74.1	10.5	50.0	74.0	45
4.0	3.1 ...	...	297.9	310.0	69.4	.672	30	189	195
125	0 10	0.20	73.9	94.5	76.0	10.8	84.7	127.5	105
2.0	0.8 ...	...	74.8	95.4	81.8	.599	26	206	213
126	0 28	0.05	3.0	28.3	74.2	1.1	12.4	16.9	31
3.5	2.9 ...	...	1.5	26.8	74.6	.773	28	262	327

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 16/17, 1931					
127	1^h09^m	$0^s.14$	309°.4	344°.7	77°.7	2°.8	24.7	34.7	38
4.0	3.0 ...	...	304°.2	339°.5	78°.0	.660	29	251°	299°
128	1 33	0.10	300.7	342.0	68.1	11.0	150.0	226.0	201
1.5	0.4 ...	...	287.9	329.2	66.1	.629	30	209	214
129	148	0.20	115.8	160.9	75.0	4.2	50.7	75.0	52
3.5	1.6 ...	...	123.2	168.3	75.5	.442	26	202	213
130	2 02	0.24	293.5	342.1	67.3	4.4	21.3	29.6	14
2.5	1.5 ...	...	292.8	341.4	65.0	.655	30	152	75
131	2 12	0.10	22.1	73.2	57.7	7.7	84.8	127.5	108
0.5	0.2 ...	...	20.1	71.2	60.9	.873	25	219	227
132	2 37	0.12	308.9	6.2	82.7	5.8	67.4	101.2	114
3.8	2.7 ...	...	310.7	8.	85.2	.620	28	299	312
133	2 43	0.10	76.9	135.8	70.5	5.6	87.2	131.6	109
3.0	1.7 ...	...	81.6	140.5	72.2	.574	24	203	206
134	3 12	0.11	342.8	48.9	59.5	6.6	68.3	102.8	79
2.5	2.2 ...	...	337.0	43.1	61.2	.868	27	205	214
135	3 15	0.14	346.6	53.5	69.9	2.0	11.4	15.5	12
4.5	4.0 ...	...	343.9	50.8	70.1	.808	26	198	338
136	3 20	0.09	296.0	4.1	78.8	2.9	39.0	57.0	34
4.0	2.9 ...	...	290.5	358.6	78.5	.617	29	208	231
137	3 26	0.05	355.0	64.6	67.7	4.7	51.2	76.0	59
5.0	4.5 ...	...	352.6	62.2	69.3	.822	26	221	238
138	3 32	0.05	346.0	57.1	76.2	4.2	74.7	111.0	86
4.0	3.3 ...	...	339.0	50.1	77.5	.725	27	200	204
139	3 36	0.21	302.5	14.6	77.7	6.9	44.3	65.2	38
2.5	1.4 ...	...	290.3	2.4	76.0	.633	29	166	156
140	3 43	0.12	335.7	49.6	60.5	8.4	69.0	103.7	78
3.0	2.6 ...	...	328.2	42.1	61.9	.838	27	198	204
141	3 50	0.14	337.5	52.8	74.4	3.8	21.5	29.8	36
4.0	3.4 ...	...	333.4	48.7	72.7	.770	26	98	54

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 16/17, 1931					
142	4^h03^m	$0^s.12$	$285^0.5$	$4^0.4$	$57^0.9$	$5^0.5$	60.0	89.8	64
2.8	1.5 ...	...	$280^0.5$	$359^0.4$	$57^0.6$	.560	30	205^0	213^0
143	4 07	0.50	135.3	215.2	74.5	6.1	32.2	46.1	37
3.0	0.3 ...	...	140.3	220.2	72.0	.321	29	234	273
144	4 25	...	25.0	109.3	82.1	4.4	(56.7)	91.0	66
2.8	1.8 ...	<0.1	26.7	111.	83.8	.651	27	197	204
145	4 47	0.05	311.9	41.8	59.4	5.9	94.2	142.0	120
3.5	2.8 ...	...	306.7	36.6	59.9	.740	27	194	197
				Oct. 17/18, 1931					
146	23 42	0.05	271.9	286.5	80.6	6.1	151.5	228.0	202
4.0	2.6 ...	...	266.8	281.4	77.6	.555	30	206	210
147	0 10	0.15	311.2	333.0	64.5	9.0	76.0	114.4	85
2.5	1.8 ...	...	305.9	327.5	61.5	.730	30	189	193
148	1 30	0.08	340.3	21.9	82.4	5.5	72.6	109.2	82
4.0	3.0 ...	...	322.8	4.4	81.5	.662	28	185	198
149	1 37	0.10	54.2	97.5	73.7	12.0	157.5	237.0	213
0.8	—0.2 ...	...	48.2	91.5	79.0	.663	26	193	195
150	1 42	0.05	6.3	50.9	63.0	5.7	48.9	72.2	84
3.8	3.5 ...	...	8.0	52.6	65.2	.860	26	286	304
				Oct. 21/22, 1931					
151	1 43	0.13	4.0	52.9	67.7	5.7	46.5	68.6	44
3.5	3.1 O	...	356.9	45.8	68.4	.835	27	198	210
152	2 22	0.16	319.6	18.2	76.6	3.9	33.6	48.8	21
2.2	1.4 O	...	311.8	10.4	76.2	.700	29	191	207
153	2 36	0.20	17.3	79.4	61.1	4.8	40.3	59.0	47
3.0	2.7 O	...	16.7	78.8	63.1	.870	23	227	249
154	2 45	0.53	200.7	265.	86.9	5.2	16.1	22.0	36
2.5	0.9 ...	...	174.7	239.	84.9	.510	28	269	321
155	3 07	0.12	275.3	345.3	63.3	3.6	59.4	89.0	60
3.2	1.7 O	...	272.8	342.7	62.1	.522	30	188	192

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_Z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_Z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Oct. 21/22, 1931					
156	3^h11^m	$0^s.14$	$272^0.2$	$343^0.1$	$61^0.2$	$5^0.3$	66.8	100.2	72
1.0	—0.7 O	...	$269^0.1$	$340^0.0$	$59^0.3$	.481	30	198^0	206^0
157	3 31	0.13	19.0	94.9	69.7	5.7	47.8	70.4	77
3.8	3.3 ...	...	25.8	101.7	70.3	.790	23	276	293
158	3 36	0.23	350.2	67.3	77.8	3.9	17.9	24.8	38
3.8	3.0 ...	...	354.2	71.3	78.9	.722	26	275	119
159	4 03	0.14	355.9	80.0	75.2	4.2	23.3	32.8	28
2.5	1.9 ...	...	348.9	73.0	74.7	.768	26	126	75
160	4 11	0.05	331.1	57.0	85.9	2.0	17.7	24.6	28
3.5	2.4 ...	...	318.1	44.	86.5	.610	28	243	308
161	4 13	0.13	332.7	59.0	70.6	6.0	38.3	56.0	32
3.0	2.4 O	...	325.8	52.1	72.2	.756	27	197	211
162	4 17	0.14	59.4	146.7	76.7	3.9	35.8	52.0	48
3.5	2.6 ...	...	50.7	138.0	77.9	.670	25	112	84
163	4 20	0.13	315.3	43.4	72.8	3.2	28.2	40.5	20
3.5	2.7 O	...	310.8	38.9	73.6	.699	27	207	244
164	4 53	0.23	330.6	66.9	70.9	6.2	27.9	40.0	18
0.8	0.1 O	...	322.4	58.7	72.6	.740	26	201	231
				Oct. 30/31, 1931					
165	19 28	0.80	19.0	342.8	63.2	11.0	15.6	21.3	28
3.2	2.9 ...	...	7.3	331.1	62.7	.882	30	243	316
166	19 49	0.14	292.1	261.1	66.0	2.5	17.8	24.8	36
4.0	3.0 Ra	...	290.8	259.8	65.2	.640	30	261	317
167	20 41	0.24	271.8	253.8	74.4	5.3	30.5	43.7	37
3.5	2.1 ...	...	271.4	253.4	72.3	.548	30	236	279
168	22 49	...	181.2	195.2	79.6	2.5	(17.7)	26.9	47
3.5	1.4 ...	0.3	181.2	195.2	78.2	.400	28	297	329
				Oct. 31/Nov. 1, 1931					
169	20 08	...	35.6	10.4	74.4	3.8	(12.4)	19.1	22
4.0	3.3 ...	0.35	28.8	3.6	74.4	.750	30	226	320

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1' AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
			Oct. 31/Nov. 1, 1931						
170	20h16m	0s.9	230°.8	207°.6	68°.8	5°.2	14.6	20.0	47
1.5	—1.2 ...	...	222°.7	199°.5	69°.0	.322	28	26°	11°
171	23 11	0.34	307.4	328.	83.4	5.2	16.7	22.8	8
2.2	1.2 ...	...	303.3	323.9	81.4	.640	30	188	335
172	0 02	...	49.2	82.5	54.2	8.0	(45.0)	74.6	76
4.0	3.3 ...	0.2	52.5	85.8	56.7	.740	24	266	284
173	0 37	0.12	309.7	351.7	54.0	4.7	35.1	51.0	48
3.0	2.3 ...	...	306.2	348.2	54.0	.750	29	248	283
174	0 48	...	269.1	313.9	67.5	3.8	(18.6)	29.0	48
3.5	1.9 ...	0.35	265.0	309.8	68.2	.500	30	292	326
			Nov. 1/2, 1931						
175	19 41	...	30.9	0.9	52.5	3.7	(12.3)	18.6	47
3.0	2.7 ...	0.3	34.4	3.4	52.9	.870	30	29	12
176	20 09	1.10	290.9	266.9	76.0	8.5	13.2	18.1	28
2.5	1.4 ...	...	286.4	262.4	72.0	.620	30	247	323
177	20 17	...	241.2	219.2	63.0	7.2	(25.5)	39.5	46
3.5	0.7 Ra	0.8	241.2	219.2	60.0	.300	29	263	302
178	20 24	0.28	292.6	272.4	69.2	4.4	28.5	40.5	46
4.5	3.4 Ra	...	289.1	268.9	67.5	.630	30	260	300
179	21 01	...	141.0	130.0	86.5	5.4	(18.0)	28.4	41
5.0	3.4 Ra	0.5	168.0	157.0	86.2	.509	28	274	317
180	21 06	0.20	338.7	329.0	85.9	8.4	64.2	96.5	94
4.5	3.3 ...	...	296.2	286.2	84.3	.606	29	257	274
181	21 16	...	280.3	273.1	71.2	3.6	(25.5)	40.8	27
3.5	2.3 ...	0.2	280.1	272.9	69.9	.590	30	221	266
182	22 41	0.14	279.0	293.0	67.7	4.1	44.4	65.5	67
3.8	2.4 Ra	...	274.6	288.6	66.9	.557	30	260	286
183	22 43	0.12	58.4	73.0	86.7	2.5	40.7	59.5	59
4.8	3.6 ...	...	50.4	65.0	87.9	.600	29	254	282

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ωz deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 1/2, 1931					
184	23^h33^m	...	179°.4	152°.4	80°.1	6°.0	(28.3)	45.3	51
3.5	1.7 Ra	$0^s.4$	138°.6	165°.6	79°.1	.450	27	265°	297°
185	23 45	...	252.3	282.3	73.8	3.6	(32.5)	52.9	64
4.0	2.2 Ra	0.2	247.2	277.2	73.2	.460	30	279	306
186	23 50	0.20	19.5	50.8	66.9	7.5	45.6	67.2	39
3.6	3.2 ...	...	10.4	41.7	67.2	.846	29	186	191
187	0 01	0.26	155.6	190.4	78.5	4.7	42.8	63.0	71
3.8	1.6 Ra	...	159.4	193.4	76.6	.382	28	274	297
188	0 44	0.45	285.8	330.6	53.0	5.1	16.8	23.0	34
2.5	1.2 Ra	...	282.5	327.3	53.0	.561	28	263	318
				Nov. 2/3, 1931					
189	19 16	0.80	323.7	287.5	73.5	5.5	8.8	11.9	32
3.8	3.1 ...	...	316.1	279.9	71.5	.740	30	266	338
190	20 27	0.24	305.7	287.3	66.1	4.5	21.4	29.7	37
4.2	3.4 ...	...	302.5	284.1	64.5	.702	30	257	309
191	21 06	0.85	295.8	287.1	63.9	9.4	15.1	20.7	33
1.2	0.1 ...	...	289.1	280.4	61.3	.623	30	260	322
192	21 14	0.24	81.7	75.0	89.1	3.5	16.0	21.8	36
4.5	3.2 ...	...	226.7	220.	89.6	.575	29	269	323
193	21 26	0.34	261.8	258.1	64.7	5.7	29.6	42.5	50
3.5	1.5 ...	...	258.3	254.6	62.4	.429	30	264	301
194	21 36	...	35.9	34.7	68.9	3.0	(32.5)	53.0	73
3.5	2.9 ...	0.1	36.9	35.7	70.1	.770	29	305	324
195	21 55	1.20	65.2	68.8	70.8	16.0	18.7	26.0	37
0.0	—1.2 ...	...	77.8	81.4	77.0	.607	28	267	311
196	22 35	0.70	10.1	23.7	69.2	10.1	15.2	20.8	35
2.0	1.5 ...	...	359.3	12.9	72.7	.792	30	265	324
197	22 42	...	311.9	327.2	56.7	4.3	(23.8)	38.7	52
3.8	3.2 ...	0.2	308.9	324.2	57.2	.760	29	280	313

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 2/3, 1931					
198	23^h06^m	...	336°.6	357°.9	67°.7	3°.6	(36.6)	60.8	41
4.0	3.5 ...	$0^s.1$	333°.3	354°.6	67°.5	.810	30	219°	245°
199	23 07	...	156.5	178.1	70.8	6.6	(91.8)	144.8	121
3.0	0.2...	0.2	165.8	187.4	71.3	.300	27	204	210
200	23 13	...	56.6	79.6	74.0	2.9	(12.0)	18.5	29
4.0	3.1 ...	0.3	52.9	75.9	73.0	.690	27	103	38
201	23 19	0.14	255.8	280.4	60.7	3.2	32.5	46.6	51
4.0	2.0	....	253.5	278.1	59.9	.420	30	259	295
202	23 51	0.75	204.9	237.5	69.6	8.5	33.1	48.0	23
2.5	—0.3 ...	...	215.4	248.0	68.9	.306	30	159	131
203	0 15	0.60	291.3	329.9	76.2	10.1	23.3	32.8	10
1.5	0.5...	...	293.1	331.7	71.7	.644	30	163	98
204	0 42	...	323.6	8.9	72.7	3.2	(12.6)	19.4	36
4.0	3.3 ...	0.3	320.6	5.9	73.6	.730	30	270	328
				Nov. 3/4, 1931					
205	19 58	0.08	286.1	261.4	73.0	2.7	39.5	57.7	84
3.5	2.4...	...	284.6	259.9	74.0	.610	30	31	22
206	20 08	...	336.7	314.5	71.6	7.5	(24.3)	39.5	50
4.0	3.4 Rb	0.35	326.2	304.0	71.1	.757	30	271	308
207	21 07	...	100.3	92.9	68.4	4.0	(26.7)	44.0	46
4.8	3.2 Rb	0.25	103.6	96.2	69.9	.500	26	259	292
208	21 29	0.50	73.7	71.7	59.6	5.7	14.2	19.4	30
2.8	1.7 Rb	...	64.8	62.8	71.1	.620	28	256	321
209	21 44	...	242.1	243.9	62.3	7.4	(64.0)	98.4	76
2.0	—0.6 ...	0.3	245.3	247.1	59.6	.330	30	215	228
210	21 52	0.76	134.9	138.7	72.2	8.7	29.4	42.2	48
2.5	—0.1 Rb	...	148.4	152.2	71.8	.333	25	263	294
211	22 02	0.70	189.1	195.4	77.2	3.9	13.2	18.1	34
3.5	1.2 Rb	...	191.6	197.9	75.8	.378	28	274	328

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ωz deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 3/4, 1931					
212	22^h25^m	...	305°.7	317°.7	64°.2	3°.9	(16.0)	25.1	37
4.0	3.2 Rb	$0^s.3$	302°.1	314°.1	64°.1	.705	30	264°	318°
213	22 48	0.46	15.4	33.2	74.0	7.0	14.7	20.2	30
3.0	2.3 Rb	...	5.8	23.6	76.4	.748	29	254	320
214	23 06	...	270.7	293.0	84.4	6.0	(23.7)	38.0	44
3.8	2.4 Rb	0.4	252.7	275.0	83.0	.543	29	262	302
215	23 16	0.58	295.9	320.7	61.7	6.8	16.3	22.3	33
2.8	1.7 Rb	...	289.8	314.6	61.5	.634	29	260	319
216	23 22	...	304.3	330.6	54.6	6.5	(22.7)	36.3	41
3.2	2.4 Rb	0.35	299.7	326.0	54.6	.700	28	259	301
217	23 33	0.13	95.3	124.3	81.9	2.4	28.3	40.7	47
4.0	2.6 Rb	...	108.0	137.0	82.9	.548	27	266	301
218	23 35	0.40	14.1	43.7	72.6	5.3	14.8	20.3	37
3.0	2.4 Rb	...	13.1	42.7	75.2	.766	29	276	327
219	0 24	...	329.6	11.4	68.8	5.4	(15.1)	24.0	38
5.0	4.4 Rb	0.4	325.1	6.9	70.6	.764	30	269	321
220	0 43	...	149.5	196.1	81.1	3.7	(24.0)	38.4	26
4.2	2.3 ...	0.3	159.7	206.3	80.7	.440	28	221	267
				Nov. 4/5, 1931					
221	20 02	0.43	96.2	73.5	74.1	6.4	19.5	27.1	38
4.0	2.7 Rc	...	98.5	75.8	77.1	.580	28	267	315
222	23 32	1.20	124.9	154.2	66.6	19.1	35.6	51.7	26
3.0	0.8 C	...	137.1	166.9	73.8	.380	26	181	181
223	23 42	...	73.7	106.0	88.8	2.4	(11.7)	17.7	46
3.5	2.2 ...	0.3	85.7	118.0	86.9	.580	28	1	0
224	23 56	1.00	40.0	75.9	82.1	14.2	16.9	23.2	31
3.2	2.5 ...	...	23.2	59.0	76.4	.741	28	106	46
225	0 00	...	21.5	58.3	78.6	2.3	(26.7)	44.5	37
5.5	4.7 ...	0.1	18.5	55.3	79.1	.710	28	234	273
226	0 08	...	98.2	137.0	69.2	4.6	(54.5)	85.0	108
2.0	0.2 ...	0.15	98.9	137.7	67.1	.469	23	351	353

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 4/5, 1931					
227	0^h15^m	$0^s.20$	313°.3	353°.9	66°.4	8°.7	50.0	74.0	58
4.0	3.2 ...	...	302°.6	343°.2	65.5	.708	30	228°	250°
228	0 31	...	61.2	105.8	69.5	3.5	(42.5)	71.0	46
4.5	3.6 C	0.1	58.8	103.4	71.0	.680	25	185	188
229	0 35	...	225.8	271.4	73.0	3.5	(23.7)	37.5	37
4.0	1.6 ...	0.35	224.3	269.9	71.7	.358	30	246	293
230	0 40	0.12	317.0	3.0	85.2	4.7	56.0	83.5	72
4.5	3.3 ...	...	292.2	339.0	85.2	.600	29	237	256
231	0 46	...	331.7	20.0	53.5	5.8	(19.2)	29.7	15
2.5	2.2 ...	0.3	327.1	15.4	52.7	.873	30	210	284
232	0 48	0.23	315.1	3.9	77.9	4.0	19.6	27.2	43
3.5	2.6 ...	...	310.6	359.4	79.2	.665	30	278	321
233	1 03	...	181.1	233.7	69.6	2.2	(48.9)	80.0	84
4.0	0.9 ...	0.15	179.9	232.5	68.7	.250	29	269	289
234	1 14	...	221.8	277.1	63.5	3.0	(56.8)	89.5	85
4.0	0.4 ...	0.2	219.8	275.1	62.6	.220	30	252	271
235	1 33	0.13	278.8	338.8	54.7	3.7	47.2	69.6	70
3.8	2.3 Rc	...	276.1	336.1	54.7	.523	29	259	283
236	1 42	...	87.6	149.9	61.0	7.7	(46.9)	73.0	82
2.0	0.3 ...	0.3	94.3	156.6	58.5	.470	21	288	302
237	1 42	...	249.7	312.0	71.1	4.9	(25.0)	39.7	49
3.8	1.8 ...	0.4	243.7	306.0	70.9	.418	30	268	306
238	1 46	0.24	72.3	135.6	60.4	5.6	32.4	46.5	51
3.5	2.3 Rc	...	76.3	139.6	61.0	.600	21	268	292
239	1 49	...	62.6	126.6	54.3	6.0	(37.5)	58.4	49
0.8	—0.1 ...	0.2	65.9	129.9	55.9	.670	19	232	250
240	2 03	...	67.1	134.7	62.7	5.4	(18.3)	28.7	24
3.5	2.4 ...	0.4	71.0	138.6	63.8	.630	22	233	281
241	2 11	...	160.9	230.5	79.7	4.4	(45.9)	72.4	74
2.8	0.7 ...	0.2	160.9	230.5	77.7	.400	29	261	284

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos z	ω_z deg/sec T_g km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 4/5, 1931					
242	2^h18^m	$0^s.40$	164.°2	235°.5	75°.9	7°.0	41.0	59.9	68
—1.0	—3.7 ...	...	163°.7	235°.0	72°.7	.320	29	271°	297°
243	2 42	...	333.0	50.3	76.9	4.0	(31.1)	50.7	23
3.5	2.7 C	0.15	325.0	42.3	76.4	.720	29	168	156
244	2 47	0.11	251.3	329.9	79.0	2.5	32.2	46.2	60
3.8	2.6 ...	...	246.6	325.2	78.8	.591	29	282	311
				Nov. 5/6, 1931					
245	19 38	...	280.7	253.0	85.7	2.2	(21.1)	33.8	54
4.5	3.2 ...	0.15	271.7	244.0	84.9	.580	29	299	326
246	19 41	...	18.4	351.4	70.9	2.3	(9.3)	13.9	21
3.8	3.3 ...	0.25	15.4	348.4	70.6	.810	30	219	336
247	20 17	0.05	46.0	28.0	84.5	4.4	74.0	111.5	140
4.0	2.8 ...	...	55.0	37.0	85.8	.601	29	342	346
248	20 27	0.70	23.1	7.7	56.9	8.5	12.0	16.3	38
1.5	1.3 ...	...	19.3	3.9	59.9	.904	30	287	336
249	20 35	0.10	83.4	70.	89.9	3.2	57.3	85.6	91
3.2	1.9 ...	...	231.4	218.	88.6	.578	29	270	289
250	20 48	...	336.4	326.2	70.4	3.5	(9.6)	13.3	38
—0.5	—1.1 ...	0.4	331.8	321.6	71.4	.782	30	301	343
251	21 35	0.90	324.6	326.2	65.1	11.7	14.3	19.6	35
1.8	1.1 ...	...	312.5	314.1	64.1	.749	30	266	325
252	21 42	0.54	102.2	105.5	85.0	6.5	17.6	24.5	30
3.8	2.4 ...	...	132.7	136.0	86.9	.540	28	250	310
253	21 50	...	69.0	74.3	67.4	5.9	(13.2)	20.3	43
4.0	2.9 ...	0.6	70.5	75.8	64.2	.630	27	52	22
254	22 06	0.42	310.6	319.9	69.2	5.6	15.4	21.1	40
3.8	3.0 ...	...	303.7	313.0	69.4	.700	30	282	329
255	22 29	0.52	237.0	252.0	84.9	10.8	32.1	46.0	49
3.5	1.7 ...	...	232.0	247.0	80.2	.465	29	258	292
256	22 49	...	23.4	43.4	53.9	3.1	(7.2)	10.9	33
3.5	3.3 ...	0.4	23.1	43.1	55.2	.900	29	282	342

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos z	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 5/6, 1931					
257	23^h23^m	...	270°.4	299°.0	72°.4	10°.5	(21.0)	31.5	37
1.5	—0.2 ...	$0^s.9$	258°.4	287°.0	69°.6	.473	30	255°	305°
258	23 26	...	145.1	174.4	71.3	4.4	(18.8)	28.6	38
3.0	0.4 ...	0.6	149.9	179.2	70.1	.330	30	261	312
259	23 34	...	55.9	87.2	59.8	5.6	(13.2)	19.9	26
3.5	2.7 ...	0.5	57.4	88.7	61.6	.720	24	251	313
260	23 35	...	12.3	43.9	81.2	4.0	(10.2)	15.7	34
4.5	3.6 ...	0.5	13.6	44.0	82.7	.670	29	276	332
261	23 41	...	29.0	62.0	76.1	5.2	(12.4)	19.1	37
4.0	3.2 ...	0.5	33.8	66.8	77.9	.710	28	284	331
262	0 39	0.10	17.2	64.8	72.1	2.4	27.1	38.2	50
4.5	3.9 ...	...	17.9	65.5	73.1	.780	28	276	310
263	0 42	...	303.1	351.4	58.6	3.5	(20.8)	32.2	22
2.5	1.7 ...	0.2	300.5	348.8	58.2	.703	30	223	286
264	1 18	...	66.0	123.3	75.9	7.0	(34.5)	55.8	47
3.0	2.1 ...	0.25	56.5	113.8	76.9	.680	26	122	94
265	1 25	...	259.9	318.9	77.2	3.6	(17.6)	27.6	42
4.5	2.9 ...	0.35	251.7	310.7	77.1	.500	30	273	318
266	1 31	...	66.6	127.2	63.9	4.2	(14.5)	22.3	21
3.2	2.2 ...	0.4	69.7	130.3	64.9	.640	22	237	297
267	2 03	...	335.3	43.9	67.2	5.0	(51.8)	85.9	65
4.0	3.5 ...	0.1	330.6	39.2	68.2	.800	29	217	232
268	2 04	0.26	270.7	339.5	58.0	4.0	29.2	41.8	39
3.2	1.4 ...	...	267.7	336.5	57.6	.467	29	244	286
269	2 09	...	192.9	262.9	70.1	2.8	(46.7)	71.4	67
2.5	—0.8 ...	0.2	191.4	261.4	69.0	.250	30	249	273
270	2 28	0.25	193.2	268.0	84.0	3.4	22.4	31.1	36
3.5	1.7 ...	...	191.0	265.8	82.0	.469	29	252	303
271	2 33	...	16.9	92.9	71.0	6.0	(13.1)	19.8	27
3.0	2.4 ...	0.5	21.1	97.1	73.4	.777	26	250	316

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 5/6, 1931					
272	2^h50^m	$0^s.20$	179°.6	259°.9	72°.5	5°.0	105.0	158.0	132
0.0	—2.9 ...	...	187°.1	267°4	72°.0	.294	30	157°	151°
				Nov. 6/7, 1931					
273	19 44	...	7.2	342.0	78.2	1.7	(40.0)	65.0	88
3.5	2.7 ...	0.05	5.1	339.9	79.0	.710	30	312	326
274	19 51	0.10	297.3	273.9	72.0	3.0	44.0	64.9	63
4.8	3.8 Rc	...	294.8	271.4	70.8	.660	30	253	280
275	20 18	...	213.8	197.1	69.0	7.0	(51.4)	82.6	76
3.8	0.9 Rc	0.4	219.9	203.2	66.8	.290	27	245	264
276	21 18	0.80	336.8	335.1	74.2	9.1	14.1	19.3	30
2.8	2.1 Rc	...	320.6	318.9	73.2	.730	30	250	321
277	21 28	...	330.2	331.0	66.6	2.2	11.7	15.9	43
1.0	0.5 ...	...	328.4	329.2	67.2	.803	30	320	346
278	21 32	0.30	64.1	65.9	67.1	4.5	21.2	29.5	36
3.2	2.3 Rc	...	64.0	65.8	69.1	.666	28	258	307
279	21 50	0.35	147.2	153.5	83.8	4.1	19.9	27.7	32
3.8	2.1 Rc	...	164.7	171.0	83.8	.488	28	251	307
280	21 54	...	289.2	296.5	70.1	2.7	(18.3)	29.6	40
5.2	4.1 Rc	0.2	285.2	292.5	69.6	.610	30	264	313
281	22 00	...	146.9	155.7	68.5	2.5	(15.1)	23.0	18
4.5	1.5 ...	0.5	149.9	158.7	68.8	.280	24	224	295
282	22 02	0.15	44.5	53.8	82.1	4.4	40.1	58.6	65
3.5	2.5 Rc	...	44.7	54.0	84.1	.637	29	269	296
283	22 43	...	300.1	319.7	57.4	4.5	(18.9)	29.5	36
3.0	2.1 Rc	0.3	296.6	316.2	57.0	.678	29	257	308
284	22 49	...	71.3	92.3	66.2	7.4	(35.2)	56.6	58
3.0	1.8 Rc	0.3	76.9	97.9	68.8	.600	25	262	287
285	1 59	...	20.1	88.7	68.0	8.7	(32.0)	50.6	65
1.5	0.9 Rc	0.3	30.1	98.7	69.4	.780	26	293	314
286	2 05	...	90.6	160.6	64.3	6.0	(13.6)	20.5	30
4.0	2.3 Rc	0.8	96.5	166.5	63.0	.470	23	269	318

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	Θ_1 Θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 6/7, 1931					
287	2^h30^m	$0^s.31$	$310^0.7$	$27^0.0$	$50^0.9$	$4^0.3$	15.0	20.5	10
3.0	2.4 ...	...	$308^0.1$	$24^0.4$	$49^0.4$	.760	30	171^0	17^0
288	2 42	...	323.9	43.2	74.9	4.7	(26.1)	42.3	18
3.5	2.7 ...	0.15	316.5	35.8	73.9	.722	29	160	128
289	2 47	...	123.1	203.7	68.5	5.1	(18.1)	27.2	35
2.5	0.0 Rc	0.7	125.6	206.2	66.5	.340	28	259	311
290	2 52	...	243.7	325.5	69.2	2.4	(18.0)	28.0	23
4.5	2.3 ...	0.3	240.9	322.7	68.4	.387	30	227	297
291	2 56	0.16	320.3	43.1	62.4	2.5	22.4	31.1	46
4.5	4.0 ...	...	319.8	42.6	63.4	.790	29	280	318
292	3 07	...	186.8	272.4	77.0	4.8	(15.0)	22.8	30
4.0	1.5 Rc	0.8	183.1	268.7	74.5	.340	30	248	315
293	3 13	...	60.3	147.3	61.4	5.0	(12.7)	19.2	25
3.5	2.6 ...	0.5	64.6	151.6	61.4	.670	22	254	313
294	3 16	...	70.1	157.9	63.8	5.5	(49.5)	79.6	56
2.8	1.7 ...	0.15	73.9	161.7	65.8	.620	24	188	191
295	3 18	...	267.1	355.4	76.2	2.8	(44.2)	72.0	42
4.0	2.5 ...	0.1	264.1	352.4	75.1	.532	30	184	187
296	3 33	0.08	246.0	338.0	83.0	2.0	23.1	32.5	38
1.5	0.0 Rc	...	242.0	334.0	82.7	.520	30	253	303
297	4 01	0.10	328.8	67.8	67.8	5.5	66.2	99.0	72
5.0	4.4 ...	...	322.8	61.8	68.1	.780	28	187	189
298	4 11	...	295.8	37.4	72.7	1.7	(21.7)	34.7	28
4.5	3.5 ...	0.1	294.1	35.7	71.8	.650	29	129	76
299	4 14	0.10	312.4	54.7	60.1	3.6	44.8	66.0	47
4.0	3.3 ...	...	309.9	52.2	60.9	.755	29	217	239
300	4 22	...	319.0	63.3	69.6	3.5	(39.2)	63.8	37
3.5	2.8 ...	0.1	315.0	59.3	69.4	.740	28	171	165
301	4 26	0.12	274.4	19.7	67.7	3.7	44.5	65.6	55
3.5	2.1 ...	...	274.9	20.2	66.0	.550	30	123	96

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ωz deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 6/7, 1931					
302	4^h29^m	...	$1^0.7$	$107^0.7$	$64^0.7$	$2^0.5$	(24.2)	39.6	19
4.0	3.7 ...	$0^s.1$	$359^0.8$	$105^0.8$	$65^0.4$	.870	24	160^0	135^0
303	4 41	0.30	67.9	176.9	70.6	5.8	28.0	40.2	19
2.8	1.7 ...	...	72.4	181.4	73.2	.620	26	158	219
304	4 51	...	228.1	339.7	75.2	2.7	(14.0)	21.0	38
3.5	1.4 ...	0.4	223.4	335.0	75.6	.410	30	273	326
305	5 10	0.20	251.6	7.9	81.2	3.0	29.8	42.9	15
4.5	2.9 ...	...	244.1	0.4	80.4	.500	29	189	208
306	5 13	...	292.8	49.8	68.6	2.7	(12.0)	18.5	40
4.0	3.0 ...	0.3	294.3	51.3	69.3	.650	29	293	335
307	5 16	...	43.4	161.2	55.8	5.8	(12.2)	18.4	13
3.0	2.5 ...	0.5	42.5	160.3	58.4	.810	21	144	61
				Nov. 13/14, 1931					
308	19 11	...	55.6	29.2	64.7	2.4	(18.9)	29.6	53
3.5	2.7 ...	0.15	55.6	29.2	65.9	.712	30	308	334
309	19 51	0.20	50.1	33.7	69.9	3.0	19.7	27.3	45
4.0	3.2 ...	...	49.6	33.2	71.2	.717	30	283	324
310	20 00	...	69.0	54.8	71.7	2.8	(9.4)	14.4	36
5.0	3.9 ...	0.4	70.2	56.0	73.6	.630	30	282	337
311	20 17	...	135.8	125.8	80.2	3.4	(15.8)	24.7	39
4.5	2.7 ...	0.4	123.6	133.6	80.5	.460	28	278	323
312	20 25	...	35.0	27.0	85.2	2.9	(26.1)	41.8	59
3.0	1.9 ...	0.15	35.0	27.0	86.7	.620	29	294	321
313	20 47	...	227.5	225.1	62.2	3.7	(15.4)	22.9	38
4.0	0.6 ...	0.85	227.5	225.1	60.9	.240	29	272	323
314	21 13	...	291.8	295.8	68.6	4.1	(18.6)	30.1	25
5.0	3.9 ...	0.3	290.0	294.0	67.1	.629	30	229	294
315	21 30	0.20	81.4	89.7	72.2	3.8	32.4	46.4	67
2.0	0.6 ...	...	85.4	93.7	73.0	.550	26	315	331
316	21 42	...	163.8	175.1	78.8	2.4	(51.8)	81.7	85
3.2	1.0 ...	0.1	167.6	178.9	78.5	.394	28	268	287

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_Z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_Z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
			Nov. 13/14, 1931						
317	22^h01^m	$0^s.12$	$258^0.5$	$274^0.5$	$86^0.3$	$2^0.3$	30.4	43.6	35
3.5	2.2 ...	...	$260^0.0$	$276^0.0$	$85^0.5$	.570	29	233^0	275^0
318	22 25	...	257.5	279.3	72.3	14.1	(7.8)	11.6	40
3.8	2.3 ...	3.0	250.4	272.4	79.5	.517	30	33	10
319	22 40	...	235.2	261.0	82.1	8.9	(36.5)	58.7	32
3.0	1.5 ...	0.4	250.6	276.4	79.0	.518	30	197	212
320	3 12	...	64.2	158.0	88.0	2.8	(48.0)	78.5	88
4.0	2.7 ...	0.08	86.2	180.0	87.7	.575	29	280	299
321	3 35	0.29	156.0	255.6	77.0	2.5	19.2	26.7	44
4.8	2.6 ...	...	154.1	253.7	75.6	.380	30	281	323
322	3 38	...	96.0	196.3	56.8	5.6	(54.3)	87.0	64
3.0	1.1 ...	0.2	100.0	200.3	58.8	.430	26	158	149
323	3 43	...	262.5	4.1	78.2	4.5	(72.5)	116.4	87
3.2	1.7 ...	0.1	258.5	0.1	76.5	.520	30	170	167
324	3 45	0.14	339.0	81.0	63.2	7.7	49.2	72.8	59
4.0	3.5 ...	...	335.9	77.9	66.7	.821	28	229	250
325	4 06	0.20	220.4	327.7	73.1	3.0	39.3	57.4	61
3.0	0.6 ...	...	215.4	322.7	73.2	.359	30	264	294
326	4 10	...	33.4	141.7	69.0	3.5	(25.0)	41.2	19
4.5	3.9 ...	0.15	31.4	139.7	70.6	.780	25	164	142
			Nov. 14/15, 1931						
327	19 16	0.25	323.3	298.9	55.5	5.4	24.0	33.7	52
3.0	2.5 ...	...	318.5	294.1	55.6	.821	29	291	322
328	19 28	0.52	67.0	45.6	82.8	4.1	12.3	16.7	45
1.5	0.3 ...	...	83.4	62.0	83.8	.585	29	345	355
329	19 49	1.50	32.1	15.9	57.8	25.3	17.7	24.2	34
0.0	—0.3 ...	...	10.6	354.4	61.7	.890	29	257	314
330	20 19	0.24	359.0	350.4	66.2	5.0	17.9	24.9	25
3.8	3.5 ...	...	353.8	345.2	65.2	.865	29	234	306

Table V. Continued.

1	2	3	4	5	6	7	8	9	10	
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0	
				Nov. 14/15, 1931						
331	20h24m	...	213°.3	205°.9	77°.2	4°.7	(64.0)	102.8	92	
3.5	1.4 ...	0s.15	219°.4	212°.0	76°.3	.409	28	242°	258°	
332	21 18	1.00	157.4	163.5	82.6	7.0	15.0	20.5	46	
4.0	2.0 ...	...	162.5	168.6	79.7	.420	28	327	346	
333	21 49	0.25	64.6	78.4	68.1	4.5	24.6	34.7	53	
4.0	3.0 ...	...	68.1	81.9	69.6	.635	28	295	324	
334	22 13	0.33	124.2	144.0	82.4	4.9	25.8	36.3	42	
3.0	1.3 ...	...	140.1	159.9	81.8	.482	28	279	308	
335	2 21	0.41	17.1	98.9	67.8	8.7	24.1	34.0	48	
4.0	3.5 ...	...	26.0	107.8	69.9	.794	26	284	316	
336	2 32	...	49.7	134.3	67.6	2.1	(12.1)	18.3	41	
3.5	2.8 ...	0.2	51.0	135.6	66.9	.730	24	335	349	
337	2 35	...	345.8	71.2	60.9	4.3	(40.9)	68.6	54	
4.5	4.2 ...	0.1	343.3	68.7	62.4	.873	29	229	252	
338	2 42	0.27	307.9	35.0	74.2	6.3	27.4	38.5	61	
4.0	3.1 ...	...	308.8	35.9	77.2	.684	30	303	328	
339	2 48	0.21	288.7	17.3	52.7	4.7	35.4	51.2	37	
2.8	1.6 ...	...	284.8	13.4	52.7	.585	29	225	258	
340	2 54	...	292.2	22.3	55.9	3.0	(13.7)	20.7	15	
3.5	2.4 ...	0.3	289.4	19.5	55.7	.623	30	210	318	
341	3 01	...	201.8	293.6	66.3	3.8	(30.7)	44.8	55	
0.0	—3.7 ...	0.5	199.2	291.0	65.6	.209	30	272	305	
342	3 12	0.05	234.4	329.0	84.2	2.4	70.5	105.6	82	
3.8	2.2 L	...	234.9	329.5	83.0	.511	30	149	139	
343	3 32	...	335.2	74.8	70.5	0.0	0.0	0.0	29	point
3.0	2.5 ...	...	.....	.....	....	.793	29	...	0	met.
344	3 58	...	42.5	148.6	54.8	4.5	(47.5)	76.4	70	
2.0	1.5 ...	0.1	46.5	152.6	55.6	.790	21	244	260	
345	4 31	0.16	352.9	107.3	77.9	4.2	27.4	38.5	22	
4.0	3.5 ...	...	352.4	106.8	78.9	.820	26	213	254	

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 14/15, 1931					
346	4^h42^m	$0^s.15$	238°.3	355°.4	79°.5	2°.4	43.5	64.1	34
4.0	2.2 L	...	235°.8	352°.9	78°.7	.468	30	186°	191°
347	4 48	...	253.3	11.9	57.1	3.7	(64.6)	98.7	70
2.0	—0.7 L	0.15	251.5	10.1	55.7	.318	29	171	167
348	5 07	0.14	24.8	148.2	67.5	6.4	48.2	71.4	40
3.5	3.0 L	...	23.3	146.7	70.3	.803	25	167	160
				Nov. 16/17, 1931					
349	23 31	0.42	9.4	50.8	73.4	11.2	27.7	39.0	16
2.5	1.9 ...	...	353.2	34.6	74.1	.776	30	203	249
350	23 33	...	127.3	169.1	68.0	5.7	(52.7)	83.0	85
3.0	0.2 ...	0.3	132.7	174.5	67.4	.308	26	264	282
351	23 48	1.60	177.5	233.1	72.6	34.5	54.6	81.3	52
3.8	1.3 L	...	230.5	276.1	68.3	.352	30	176	174
352	23 52	0.70	114.2	160.8	62.8	5.2	21.6	30.0	36
3.2	0.5 ...	...	118.9	165.5	62.3	.320	23	264	304
353	23 54	...	77.5	124.9	57.2	60.4	(53.4)	87.0	58
2.8	2.3 L	1.2	7.5	54.6	72.5	.811	29	176	174
354	0 03	0.10	93.2	142.6	57.9	4.8	86.6	130.4	139
3.5	1.7 E	...	97.0	146.4	57.6	.455	21	289	298
355	0 09	0.10	261.2	312.0	65.4	4.0	83.7	126.0	123
4.0	2.1 E	...	257.0	307.8	64.9	.442	29	258	271
356	0 16	...	204.8	257.4	80.3	16.7	25.7	36.2	7
3.8	1.9 L	...	237.3	289.9	75.4	.443	30	177	161
357	0 30	...	31.6	87.7	55.8	4.0	(13.4)	20.2	36
3.0	2.6 ...	0.3	35.5	91.6	57.5	.852	26	284	328
358	0 33	1.10	161.3	218.1	69.0	9.2	28.3	40.7	12
4.0	1.0 L	...	173.2	230.0	68.6	.279	29	182	188
359	0 38	0.40	203.9	262.	83.3	12.1	60.3	90.3	61
3.5	1.9 L	...	234.4	292.5	80.1	.504	30	176	175

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 16/17, 1931					
360	0^h41^m	...	347°.7	46°.5	67°.0	5°.6	(3.6)	5.4	31
4.8	4.5 ...	$1^s.5$	350°.9	49°.7	66.0	.868	30	82°	8°
361	0 46	0.50	100.8	160.9	78.9	7.8	30.4	43.7	52
1.5	—0.2 E	...	115.3	175.3	77.9	.481	28	269	302
362	0 47	...	262.7	323.1	79.9	4.3	(70.0)	113.8	109
4.0	2.4 D	0.1	259.5	319.9	79.3	.511	30	252	267
363	1 13	0.40	153.2	220.0	67.2	10.9	103.5	153.0	124
1.5	—1.8 L	...	166.4	233.2	67.7	.247	29	180	180
364	1 19	0.13	322.1	30.5	66.3	5.8	40.5	59.2	66
3.5	2.9 E	...	317.1	25.5	68.1	.757	30	270	296
365	1 20	0.24	307.7	16.3	57.4	4.0	17.0	23.3	40
4.0	3.3 E	...	304.9	13.5	57.9	.740	30	273	323
366	1 35	...	135.6	208.0	62.4	4.9	(37.8)	55.2	29
—0.5	—4.1 L	0.5	139.6	212.0	62.5	.218	27	188	196
367	1 37	0.11	141.3	214.1	69.0	4.8	145.5	219.0	190
3.0	0.2 L	...	146.7	219.5	69.8	.308	29	180	180
368	1 46	...	284.2	359.3	61.9	5.5	(27.5)	44.0	15
2.8	1.5 L	0.3	282.3	357.4	58.9	.572	29	174	162
369	1 50	...	113.9	190.	83.0	3.0	(47.5)	78.7	50
5.0	3.5 L	0.1	117.9	194.	84.2	.530	29	185	188
370	1 50	...	201.4	277.5	72.2	4.2	(77.8)	124.8	96
4.0	1.2 L	0.15	205.0	281.1	70.3	.300	30	194	198
371	1 53	...	190.6	267.4	78.2	9.8	(74.0)	111.6	84
0.5	—1.8 L	0.3	208.0	284.8	76.5	.377	30	163	158
372	2 00	...	140.8	219.4	65.1	4.1	(45.3)	70.6	43
3.0	—0.2 L	0.3	144.1	222.7	65.7	.259	29	166	157
373	2 10	0.33	18.6	99.7	76.1	15.8	52.6	78.3	50
3.0	2.3 L	...	353.8	74.9	76.9	.739	29	166	159
374	2 13	...	126.5	208.3	65.2	3.7	(48.5)	76.6	54
3.5	0.8 ...	0.2	130.2	212.0	66.2	.320	28	152	138

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 16/17, 1931					
375	2^h16^m	$0^s.45$	$64^0.2$	$146^0.8$	$60^0.2$	$10^0.6$	34.5	50.1	27
0.0	—0.9 L	...	$61^0.7$	$144^0.3$	$65^0.5$	.684	24	170^0	160^0
376	2 26	...	316.5	41.6	68.0	8.0	(44.7)	72.7	46
3.0	2.3 L	0.2	309.9	35.0	65.6	.751	30	159	145
377	2 29	0.50	317.0	42.8	76.4	9.8	27.5	38.7	9
2.5	1.6 L	...	299.8	25.6	75.1	.668	30	180	180
378	2 41	...	82.2	171.0	53.3	6.0	(47.2)	69.9	49
—2.0	—3.5 L	0.2	83.3	172.1	55.9	.530	22	167	162
379	3 04	...	204.4	299.0	70.8	2.2	(31.7)	51.2	58
4.5	1.6 ...	0.2	201.9	296.5	70.5	.290	30	267	298
380	3 05	...	289.7	24.5	57.4	6.2	(30.0)	48.6	22
3.5	2.3 L	0.3	286.5	21.3	55.1	.591	30	164	141
381	3 08	0.24	70.8	166.4	56.5	5.0	34.0	49.4	28
—1.0	—2.1 L	...	72.7	168.3	58.2	.610	22	177	175
382	3 11	0.35	262.9	359.3	59.2	6.8	46.7	68.9	41
0.5	—1.7 L	...	260.3	356.7	56.4	.390	29	175	171
383	3 20	...	162.6	261.2	73.4	3.9	(49.3)	78.8	54
3.5	0.9 L	0.2	168.6	267.2	73.2	.329	30	155	142
384	3 24	...	146.3	245.9	79.6	12.3	(128.0)	179.0	149
—5.0	—7.1 L	0.2	172.3	271.9	77.5	.400	30	175	174
385	3 38	0.32	170.7	273.8	69.3	4.2	52.4	77.6	49
2.5	—0.9 L	...	174.5	277.6	68.8	.236	30	170	164
386	3 43	0.35	72.4	176.8	61.7	8.8	43.2	63.7	39
1.0	—0.2 L	...	76.9	181.3	65.2	.598	25	175	172
387	3 45	...	237.3	342.1	64.4	5.2	(38.1)	59.8	31
3.0	0.1 L	0.4	236.1	340.9	62.5	.288	29	182	184
388	3 50	...	203.1	9.2	71.1	6.1	(21.6)	34.5	12
5.0	3.3 L	0.5	261.2	7.3	68.1	.480	30	160	105

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_Z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_Z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 16/17, 1931					
389	3^h52^m	...	213°.3	319°.9	80°.1	6°.9	(35.0)	53.1	25
0.5	—1.6 L	$0^s.4$	222°.3	328°.9	76°.5	.417	30	170°	158°
390	4 04	...	165.1	274.7	67.3	4.2	(42.5)	69.1	39
1.5	—2.2 L	0.4	168.2	277.8	66.5	.208	30	177	175
391	4 10	...	216.8	327.9	83.4	7.3	(66.4)	104.7	76
2.5	0.7 L	0.2	222.0	333.1	80.2	.460	30	167	162
392	4 12	0.27	78.9	190.5	70.4	4.5	28.3	40.5	18
3.0	1.7 ...	...	81.5	193.1	72.6	.582	27	159	126
393	4 19	0.05	272.1	25.5	73.9	4.5	114.0	172.0	142
3.5	2.0 L	...	260.9	14.3	73.1	.527	30	180	180
394	4 22	0.82	356.5	110.6	67.2	21.8	28.7	41.3	50
5.0	4.5 E	...	22.7	136.8	70.7	.793	25	275	305
395	4 22	0.22	337.8	91.9	72.0	4.0	23.4	33.0	20
3.5	2.7 D	...	331.5	85.6	71.9	.722	28	142	84
396	4 29	0.22	32.9	148.7	66.3	6.8	36.8	53.4	30
1.5	0.9 L	...	32.4	148.2	68.7	.789	25	172	166
397	4 38	...	308.5	66.6	61.0	8.5	(51.4)	81.1	52
2.0	1.1 L	0.2	300.5	58.5	61.0	.690	29	184	186
398	4 40	0.21	83.1	201.7	63.6	4.4	39.7	58.0	32
3.0	1.5 L	...	86.9	205.5	65.1	.530	27	172	167
399	4 42	0.12	145.9	265.0	74.5	4.8	87.8	132.0	103
0.8	—1.7 L	...	152.6	271.7	74.1	.350	30	169	166
400	4 45	...	292.1	51.9	70.7	5.3	(25.2)	41.0	12
4.0	2.8 L	0.3	285.7	45.5	70.4	.600	30	187	204
401	4 47	...	329.2	89.6	69.7	5.2	(37.8)	63.6	57
4.5	3.9 D	0.15	329.6	90.0	72.1	.759	28	243	269
402	5 10	0.08	46.4	172.5	61.0	6.0	48.1	71.2	50
3.0	2.3 ...	...	50.1	176.2	62.3	.749	24	203	204
403	5 14	...	273.7	40.8	66.6	5.1	(33.3)	53.6	26
3.0	1.4 L	0.25	264.8	31.9	65.4	.510	30	166	151

Table V. Continued.

1	2	3	4	5	6	7	8	9	10
No. m	t m_Z rad.	dur. est.	θ_1 θ_2	AR_1 AR_2	δ_1 δ_2	L Cos$z$	ω_Z deg/sec Tg km/sec	T km/sec P	T_0 km/sec P_0
				Nov. 16/17, 1931					
404	5^h17^m	$1^s.37$	$90^0.7$	$218^0.5$	$75^0.8$	$13^0.0$	17.3	23.7	34
3.8	2.2 E	...	$97^0.3$	$225^0.1$	$70^0.1$	.497	29	259^0	316^0
405	5 24	...	260.3	29.9	62.9	5.0	(30.5)	48.2	18
3.0	0.9 L	0.35	256.8	26.4	62.1	.400	30	176	169
406	5 29	...	342.3	113.1	75.7	12.8	(53.8)	81.1	54
—1.5	—2.4 L	0.3	319.5	90.3	78.9	.680	28	169	163

executed on the basis of directly observed mean heights of the shower meteors, determined separately for each shower; therefore the velocities of the shower meteors as quoted in Table IV are not identical with their velocities found in the procedure of standardization; also a slight systematic difference in the velocities of the shower meteors of the table may have been produced in such a manner.

The lower figure of the 9th column gives P, the apical direction of motion of the meteor; the angle P is counted counterclockwise from the direction toward the orbital apex of the earth, $P = 0^0$ thus corresponding to an apparent motion from the antapex toward the apex. The last, 10th column, contains T_0, the heliocentric tangential velocity, and P_0, the heliocentric apical direction of motion of the meteor; these figures define the motion of the meteor, freed from the effect of the orbital motion of the earth and projected on the plane at right angles to the line of sight; the vector (T_0, P_0) is evidently the geometric sum of the vectors (T, P) and $(T_g, 0)$; the geometric summation was made graphically; the perturbing effect of the earth's gravitational field (zenithal attraction) is, however, still contained in both T_0 and P_0, being fortunately small in most cases; for obvious reasons the correction for the earth's attraction cannot be made individually when only projected velocities are observed. The remarks behind the table refer chiefly to trains (tr.) and their durations (in seconds).

Table V contains similar data for the Arizona observations of the writer; it differs from the preceding table in the 4th, 5th and 6th columns, where the lower line (Θ, AR, δ) refers to the coordinates of the centre of the trail, instead of the end-point, in conformance with the method of reduction applied to the Arizona results; further, the upper line of the 8th column contains ω_z [according to (11)], instead of ω quoted in Table IV. Table V contains 279 velocities derived from observed oscillations of the rocking mirror and 127 cases of estimated duration, thus approximately the same proportion as for the Tartu observations; these figures, however, need a correction: during the first lunation of the Arizona Expedition, between October 6 and 21, 1931, the writer registered only the cases with observed oscillations, omitting the rest, so that estimates of duration were not made except occasionally in one case; complete records were made only during the second lunation, between October 30 and November 16, 1931; during this period 118 cases of observed oscillations and 126 cases of estimated duration were registered; thus, in the Arizona observations of the writer the percentage of observed oscillations was 48, whereas in the Tartu observations it was 61 (both figures are, nevertheless, considerably higher than the percentage, about 20, recorded by the other two Arizona observers); the lower percentage in the first case is probably explained by the larger field of vision obtained without the reticle and the window glass, when many objects are seen by side-vision which does not favour the observation of much detail in the trail.

In Tables IV and V, column 2, the designations of the radiants of the shower meteors are:

P = Perseids; L = Leonids; G = Geminids; O = Orionids; Q = Quadrantids; Ra (AR = 42°, δ = +20°), Rb (AR = 54°, δ = +15°), Rc (AR = 56° to 64°, δ = +28° to +25°), all three active in the first days of November; A (AR = 17°, δ = +3°, Oct. 8); B (AR = 355°, δ = +35°, Oct. 13); F (AR = 32°, δ = = +5°, Oct. 13); C (AR = 135°, δ = +17°, Nov. 4); D (AR = = 84°, δ = +17°, Nov. 16); E (AR = 57°, δ = +25°, Nov. 16). The less known radiants are those found to be conspicuous in the records of the Arizona Expedition (*cf.* [6]).

4. The Relative Quality of Rocking Mirror Observations and of Estimated Durations for Different Observers. Reliable observations must satisfy the following conditions: the observational

error must be small enough; the observed and the true quantities must show a good correlation of a monotonous slope; the observations must be sensitive to differences in the measurable quantity. The smallness of the apparent observational error dispersion is not always a sufficient check of the reliability of the observations.

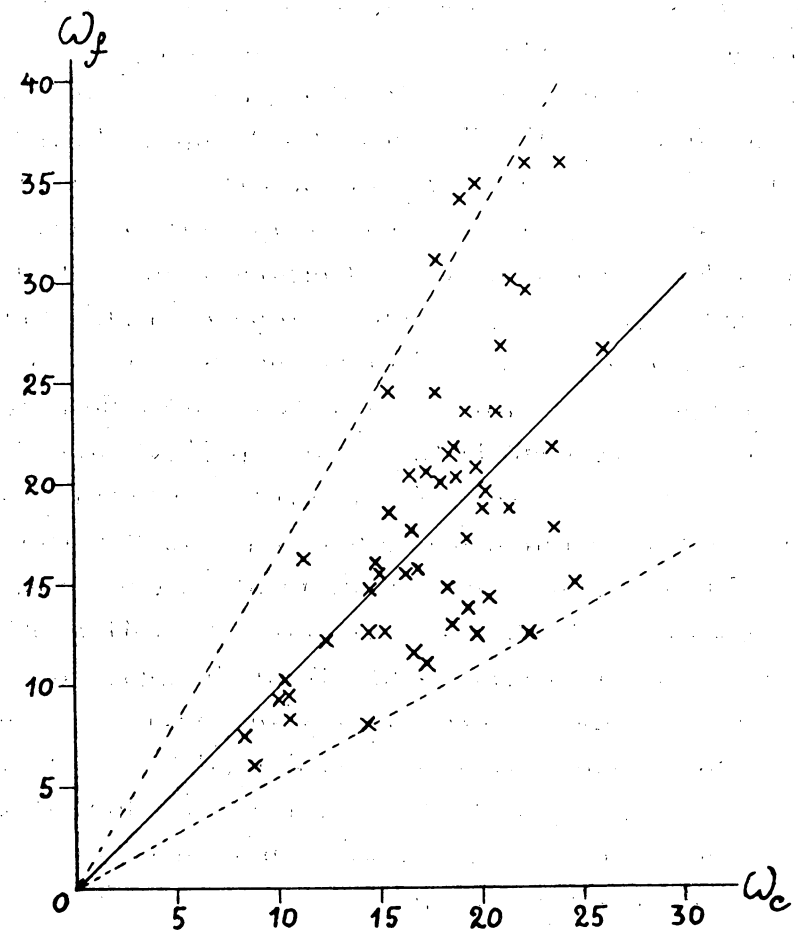

Fig. 1. Correlation of observed (ω_f) and computed (ω_c) angular velocity for the shower meteors; oscillations observed by E. Ö. at Tartu.

A small dispersion may be obtained by writing down arbitrary figures of a low dispersion, whithout any connection with the true quantity; a small dispersion of the true quantity corresponding to a given observed quantity may be the result of the smallness of the dispersion of the true quantity itself, without any influence of the accuracy of the measures. Thus, the quality of the correlation must be considered in the first place.

The correlation of the observed and computed velocities or durations for different observers is represented on Figures 1 to 8. From these figures it is obvious that the condition of reliable correlation is fulfilled for all four cases of velocities derived from

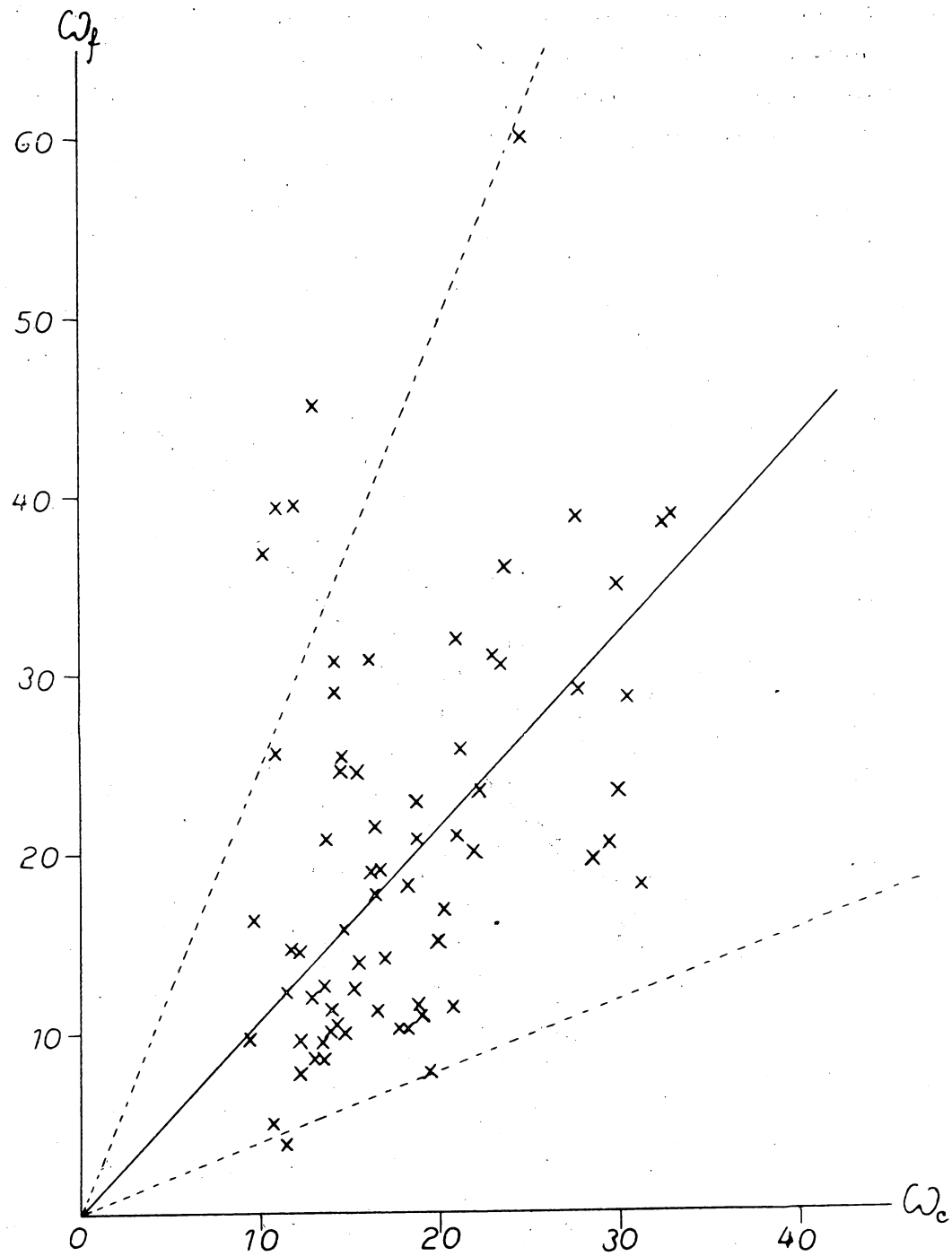

Fig. 2. Correlation of observed (ω_f) and computed (ω_c) angular velocity for the shower meteors; oscillations observed by E. Ö. in Arizona.

observed oscillations of the rocking mirror, although the material is somewhat scarce in the case of D. H. (Fig. 4); a few outstanding cases may be explained quite plausibly by stray meteors which moved accidentally in the approximate direction required. Of all the correlations, the correlation for the Tartu angular velocities by E. Ö. (Fig. 1) is doubtlessly the best one. Very good

correlations are also shown by Fig. 5 and 6, or by the estimated durations of E. Ö. On the contrary, Fig. 7 and 8 reveal bad correlations which are irregular, of a low slope, i. e. insensitive, and of a large error dispersion. These two cases refer to durations

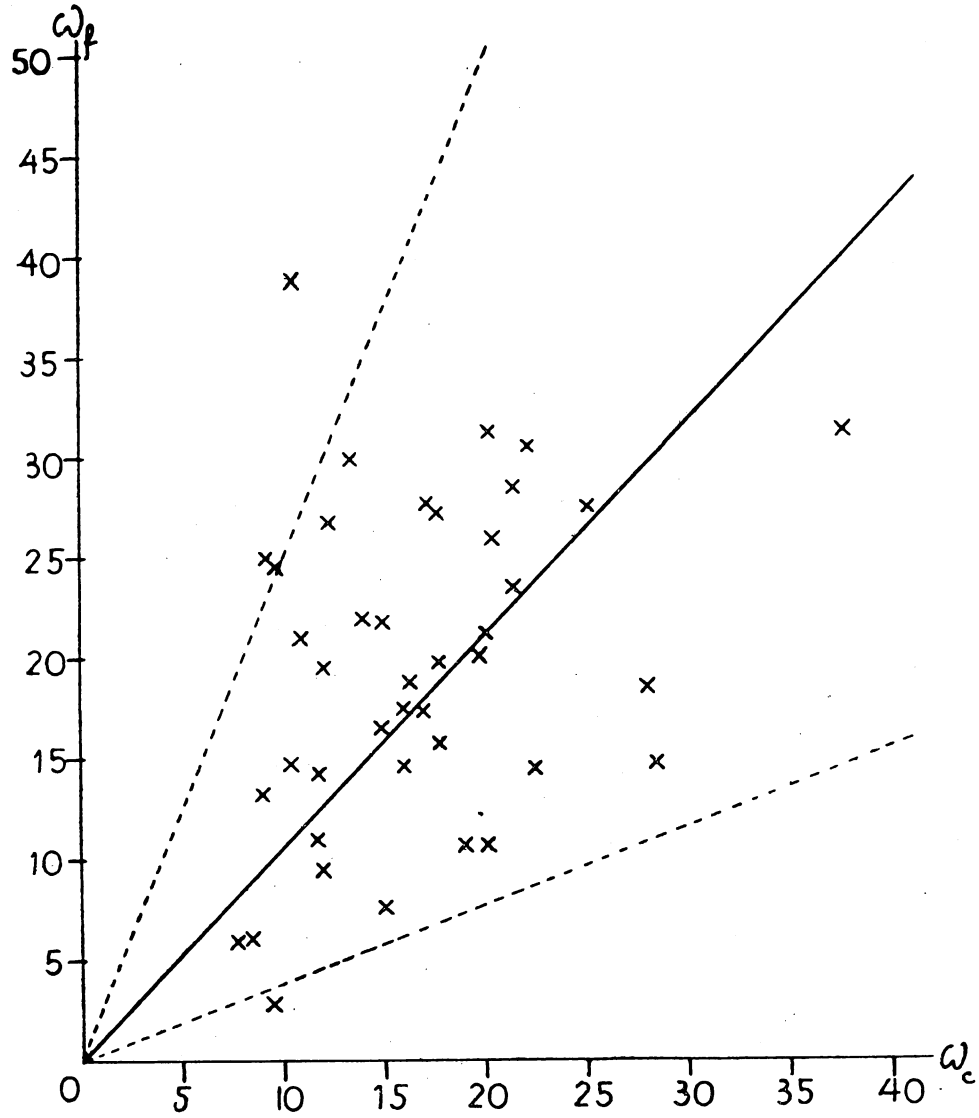

Fig. 3. Correlation of observed (ω_f) and computed (ω_c) angular velocity for the shower meteors; oscillations observed by R. W. in Arizona.

estimated by Roger Wilson (R. W.) and Donald Hargrave (D. H.) when they were observing with the rocking mirror; in addition to that, the durations estimated by the same observers without the rocking mirror, as well as the durations registered by the other two principal Arizona observers, Robert Harris (R. H.) and George Peters (G. P.) were examined on the basis of an abundant material; the correlations found in these four last

mentioned cases turned out to be at least as bad, or even worse than those shown on Fig. 7 and 8 and are not reproduced here: it was thought that Figures 7 and 8 sufficiently illustrate the character of the bad correlations for the estimated durations.

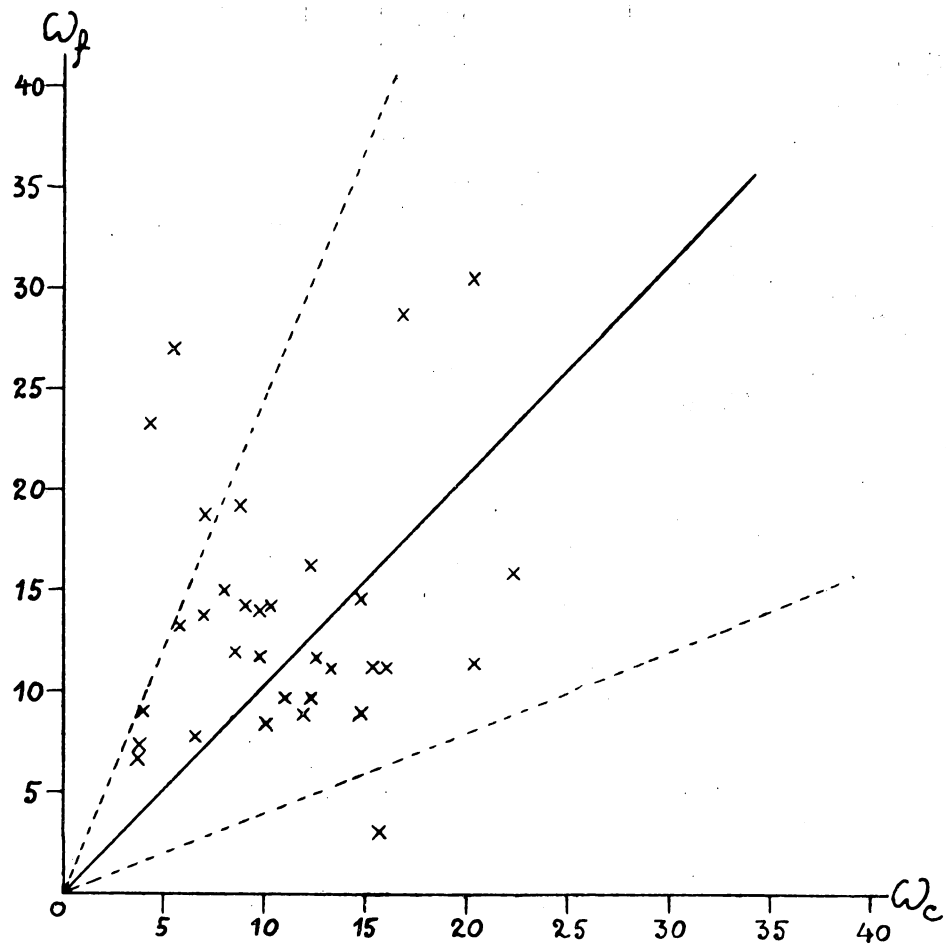

Fig. 4. Correlation of observed (ω_f) and computed (ω_c) angular velocity for the shower meteors; oscillations observed by D. H. in Arizona.

On the accompanying figures the full line represents the true correlation (drawn by neglecting a few outstanding cases, supposedly stray meteors); the two dotted lines on Fig. 1—6 represent the approximate limits of the possible observational error; the logarithmic character of the error dispersion appears to be highly probable for all these cases, as can be judged from the divergence of the dotted lines starting at the origin of the coordinates, which circumstance indicates a constant relative error in ω or τ.

The low quality of the estimates of duration obtained by the four Arizona observers (except E. Ö.) is also obvious from the

following table, referring to the true correlation, the dispersion of the estimates by E. Ö. (Tartu + Arizona) being assumed as unit of the relative error dispersion.

τ_{est}	0.1	0.2	0.3	0.4	0.5	0.6	0.8	1.0	1.2	Relative error disp.
					τ true					
R. W., rock. m.	0.04	0.30	0.68	1.23	2.04	....	....	....	....	3.0
„ , without	0.03	0.20	0.70	0.92	1.05	....	1.64	2.20	....	2.7
D. H., rock. m.	0.13	0.31	0.78	1.10	1.75	2.80	....	....	....	1.7
„ , without	0.06	0.12	0.22	0.34	0.49	0.66	1.70	2.90	....	3.0
R. H.	0.02	0.20	0.38	0.89	1.28	....	2.90	....	....	3.9
G. P.	0.03	0.10	0.24	0.42	0.61	....	1.19	....	2.08	3.1

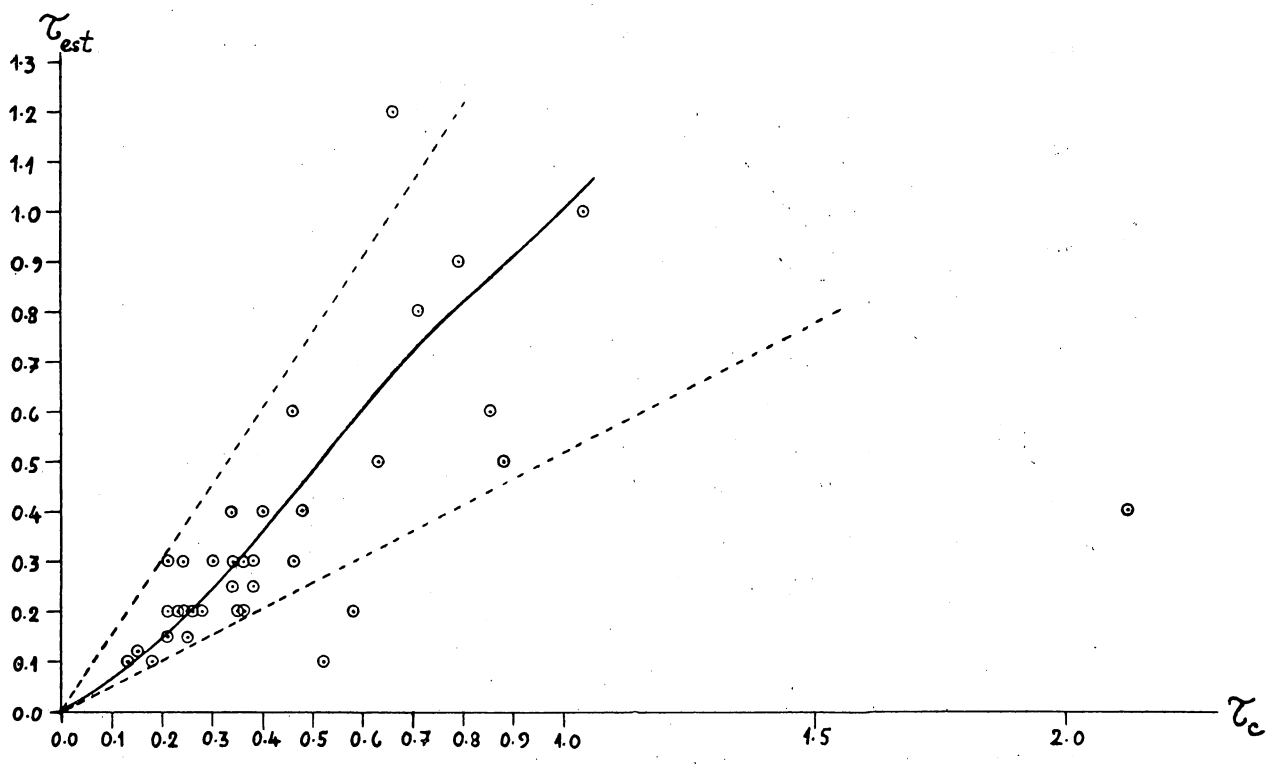

Fig. 5. Correlation of observed (τ_{est}) and computed (τ_c) duration for the shower meteors; estimates of duration at the rocking mirror by E. Ö. at Tartu.

None of the conditions of a reliable correlation (*cf.* above) is here fulfilled; the figures are of such a character that we feel justified to disregard altogether the estimates of duration made by these four observers. On the other hand, the success of the estimates obtained by E. Ö. indicates that estimated durations may

in certain cases compete in individual accuracy with rocking mirror observations.

5. *The Observational Error Function.* The derivation of the true distribution of meteor velocities cannot be made satisfactorily without a knowledge of the distribution of observational errors. The concluded spread in the meteor velocities varies according to the size of the assumed mean error; the larger the assu-

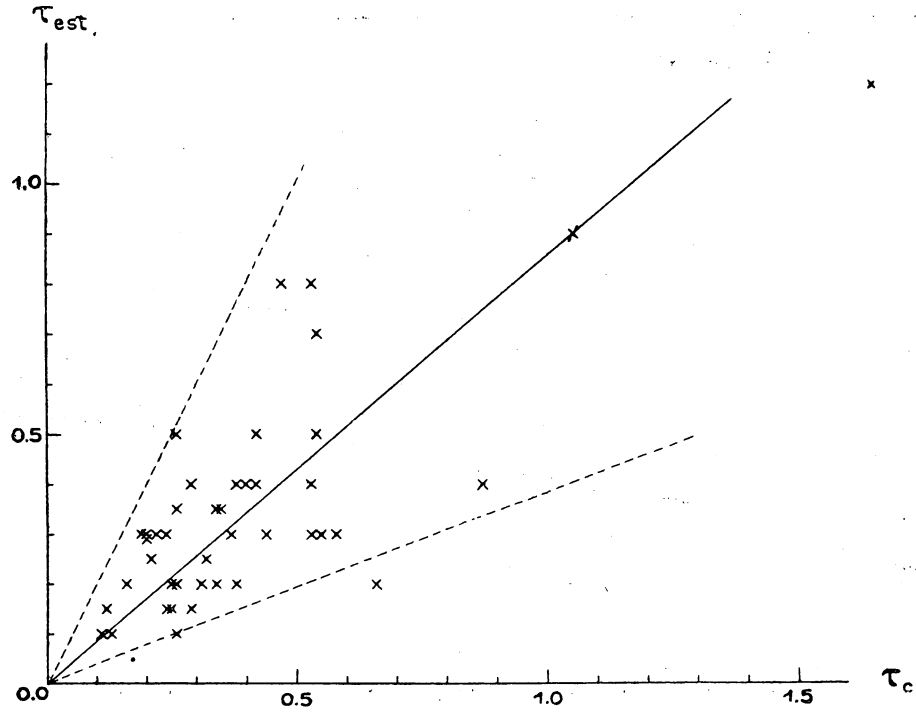

Fig. 6. Correlation of observed (τ_{est}) and computed (τ_c) duration for the shower meteors; estimates of duration at the rocking mirror by E. Ö. in Arizona.

med error, the smaller is the resulting spread of velocities. In former researches the writer, having estimated the probable size of the observational error (*cf.* [1]), found a considerable spread in the velocities of meteors; the variety in meteor velocities appeared to be much greater than anticipated by former investigators. To judge upon the reliability of this conclusion, based to some extent upon the rejection of a few large deviations considered real (stray meteors, *cf.* [1]), also to set a lower limit to the possible variety in meteor velocities, it is desirable to use in the discussion of the statistical data a value of the observational error which is intentionally overestimated. A maximum maximorum of the error dispersion we obtain by assuming that all the deviations

of observed angular velocity from the computed values are errors of observation; thus none of the shower meteors is rejected; as at least about twenty per cent of the presumedly shower meteors are stray objects for which the hypothesis of the shower radiant with parabolic velocity fails, the inclusion of all the deviations into the error function means doubtlessly overestimating the spread of the latter. Moreover, from the present material, which includes over two hundred shower meteors, the frequency function of observational errors can be derived and used, instead of simply using the mean error alone.

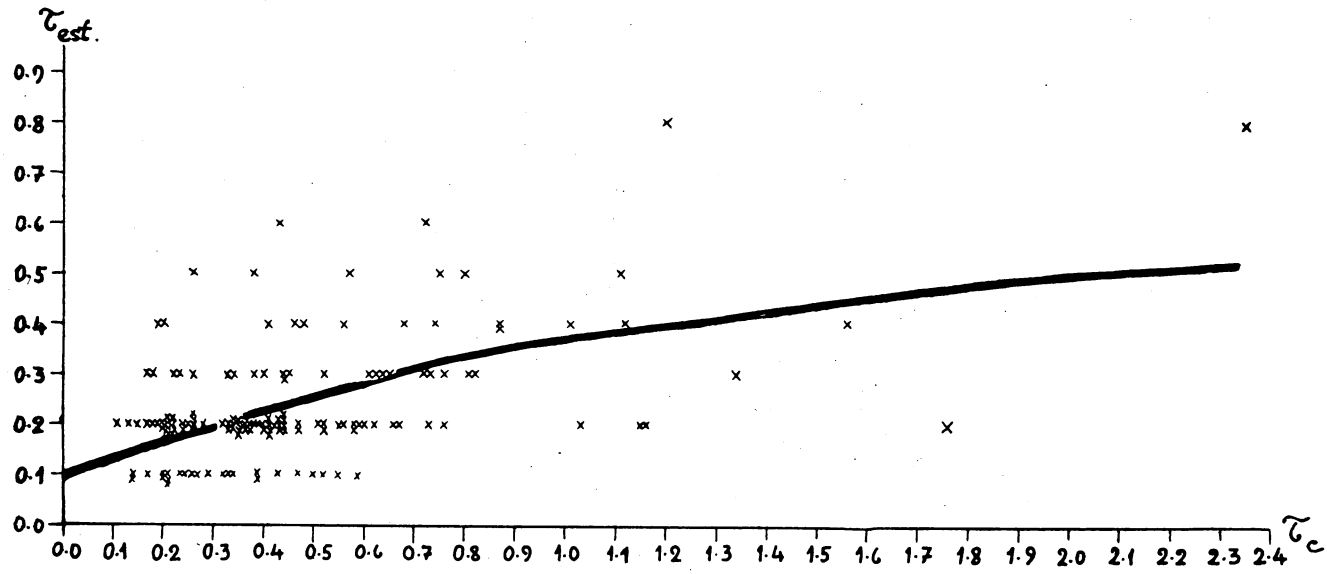

Fig. 7. Correlation of observed ($\tau_{est.}$) and computed ($_c\tau$) duration for the shower meteors; estimates of duration at the rocking mirror by R. W. in Arizona.

Table VI contains a summary of the comparison of observed (ω) and computed (ω_c) angular velocities for all the assumed shower meteors of E. Ö. The observed angular velocities are already corrected with the aid of the corresponding correction factors (f, f'). The distribution of the observational errors is a logarithmic one; therefore, the table is arranged according to logarithmic limits of the ratio $\frac{\omega}{\omega_c}$, the tabular unit of $\log\frac{\omega}{\omega_c}$ being equal to $\frac{1}{4}\log 2$, the same as used in all our statistics of meteor velocities. The distribution of the deviations $\log\frac{\omega}{\omega_c}$ is slightly asymmetrical, in spite of the fact that our correction factors

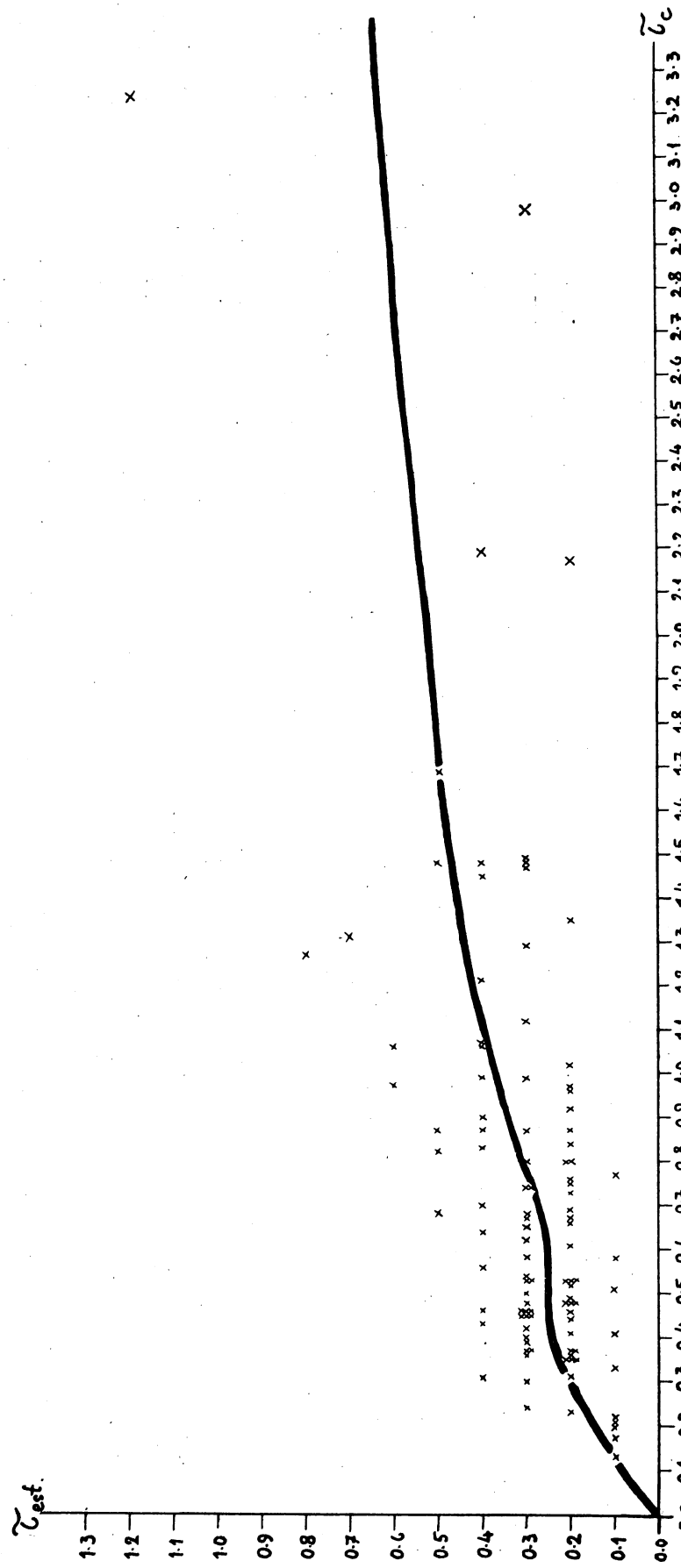

Fig. 8. Correlation of observed (π_{est}) and computed (π_c) duration for the shower meteors; estimates of duration at the rocking mirror by D. H. in Arizona.

Table VI.

Distribution of $\log\frac{\omega}{\omega_c}$ for the Shower Meteors, E. Ö.

None rejected.

$\left(\log\frac{\omega}{\omega_c}\right)$: (0,0752) limits	mean	Arizona rock. mirr.	Arizona est.	Tartu rock. mirr.	Tartu est.	All, observ.	All, smooth.	"Max. error" frequency
—7.5								
	—7	1	0	0	0	1	1	0.005
—6.5								
	—6	0	0	0	0	0	1	0.005
—5.5								
	—5	1	1	0	0	2	1	0.005
—4.5								
	—4	1	2	0	0	3	6	0.030
—3.5								
	—3	6	6	5	2	19	14	0.070
—2.5								
	—2	11	4	6	2	23	22	0.110
—1.5								
	—1	7	9	6	6	28	31	0.150
—0.5								
	0	10	9	17	7	43	44	0.220
0.5								
	+1	13	3	9	8	33	31	0.150
1.5								
	+2	6	4	5	6	21	22	0.110
2.5								
	+3	4	4	5	1	14	14	0.070
3.5								
	+4	3	1	0	0	4	6	0.030
4.5								
	+5	2	1	0	1	4	3	0.015
5.5								
	+6	0	1	0	0	1	2	0.010
6.5								
	+7	4	0	0	0	4	2	0.010
7.5								
	+8	0	0	0	1	1	1	0.005
8.5								
	+9	0	0	0	1	1	1	0.005
9.5								
Sum		69	45	53	35	202	202	1.000

(f, f') are supposed to make the mean value of $\log\omega$ equal to $\log\omega_c$; the asymmetry, however, is entirely due to a few large positive deviations of $\log\frac{\omega}{\omega_c}$, corresponding to high velocities, in which cases the meteors most probably are not real members of the corresponding showers, and the deviations are not errors of observation. Thus, if the distribution of the deviations as given in the last column of Table VI is assumed to represent the law of observational errors, the result is that the frequency of large positive errors is especially overestimated; when this "maximum error" distribution is used to free the observed distribution of velocities from the effect of observational errors, the resulting corrected distribution is believed to show a too small dispersion and to contain too few large velocities; a lower limit to the frequency of large velocities is set in this case. Further, by using the asymmetrical "maximum error" frequency of Table VI, a lower value of the mean velocity is also obtained, as compared with the velocity which would follow from the assumed value of the reduction factors (f, f'); in other words, the "maximum error" hypothesis leads probably to a minimum value of the mean velocity of meteors. The underestimate in the resulting dispersion of meteor velocities is enhanced by the fact that in the "maximum error" distribution the cosmic spread of the assumed meteor heights is fully included; the effective error dispersion is thus exaggerated by an amount corresponding to the double quadratic spread in the heights (*cf.* [1], Section 5).

The "maximum error" hypothesis as represented by Table VI serves to set certain limitations to the characteristics of the distribution of meteor velocities. The most probable distribution of velocities can be obtained, however, only by using the most probable law of observational errors; to derive such a law, we must take into account that stray meteors are partly responsible for the spread in $\log\frac{\omega}{\omega_c}$, and that this spread is influenced by the dispersion in the heights as mentioned above. The probable frequency of observational errors we derive below by a procedure which differs from the procedure applied in former papers (*cf.* [1] and [3]). Instead of an arbitrary rejecting of a few very large deviations, we try the following more definite procedure. To avoid

an arbitrary diminution of the apparent error dispersion, the stray meteors must be picked out on the basis of their observed velocities, instead of their deviations ($\log \frac{\omega}{\omega_c}$); also, the probable number of stray meteors can be computed (*cf.* [6]) from independent criteria. Let $F(T)dT$ and $F_0(T)dT$ be the observed distributions of tangential velocities for the "sporadic" and the "shower" meteors respectively, and let the fraction of stray meteors among the shower meteors be $1 - r$ (*cf.* [7], Table XXX, where the corresponding fraction is called $1 - \nu_0 r$); the stray meteors may be assumed to have the same distribution of velocities as the sporadic, or non-shower meteors; thus the distribution, or frequency function of observed velocities among the true shower meteors may be set equal to

$$[F_0(T) - (1 - r)F(T)]dT.$$

The actual application of this principle leads to fractional numbers, which is somewhat inconvenient in the present case. Instead of that, from a given group of shower meteors (grouped according to the direction, P) the supposed stray objects were marked individually; let n_s be the predicted number of stray meteors within the group; the shower meteors of this group were subdivided into n_s subgroups of observed velocity (T), the limits of velocity being chosen to satisfy the condition

$$\int_{Ti}^{Ti+1} F(T)\,dT = \frac{1}{ns}\int_0^{\infty} F(T)\,dT = \frac{1}{ns}.$$

In each subgroup one of the shower meteors was designated as stray, the choice depending also upon other criteria such as the direction of motion (the largest deviation from the expected direction), the magnitude (in the case of the Leonids which are mostly bright, so that faint objects are more likely to be stray), the length of the trail, partly also upon the ratio $\frac{\omega}{\omega_c}$ (when the other criteria were indefinite); the latter circumstance may have some influence upon the concluded size of the observational error, but the influence can be only slight.

Further, already from the data of Table VI it appears that the observations at different epochs and by different methods are of unequal accuracy, the Tartu observations appearing to be more

accurate than those obtained in Arizona. The observational error is therefore determined below separately for each set of data. The actual deviations are given in Table VII.

The deviations are printed in the order of their size. The apparent error dispersion in log ω, given in the last column of the table in units of 0.01 is the mean square of log $\frac{\omega}{\omega_c}$ for the "pure shower meteors".

The exclusion of the stray meteors has made the distribution of log $\frac{\omega}{\omega_c}$ symmetrical and very similar to a regular Gaussian, as can be judged from the following data referring to the frequency of large deviations:

	Number of deviations exceeding 1.41 times the dispersion			Number of deviations exceeding 2.12 times the dispersion		
	negative	positive	all	negative	positive	all
Observed	13	11	24	2	5	7
Theoretical	12.85	12.85	25.7	2.75	2.75	5.5

The difference between theory and observation is here well within the natural uncertainty, $\pm\sqrt{n}$; the slight excess of positive deviations is uncertain and may be explained by 2—3 stray meteors left in the list; it appears that a Gaussian represents well the law of errors.

Subtracting quadratically from the apparent error dispersion twice the spread in the heights (*cf.* [1], Section 5) assumed equal to ±0.060 (mean square devi.), the effective probable errors (to be used in the procedure of freeing the observed distribution from the influence of accidental errors) are found as follows:

	Arizona rocking mirror	Arizona estimates	Tartu rocking mirror	Tartu estimates
Probable error in log T	±0.105	±0.092	±0.039	±0.063
p. e. of probable error	±0.010	±0.011	±0.004	±0.008

Counting with the relative number of meteors observed by the two methods in Arizona and Tartu, the effective errors given

Table VII.

Individual Errors of Observation, $\log \frac{\omega}{\omega_c}$ (0.01 taken as unit).

Shower meteors, E. Ö.

	$\log \frac{\omega}{\omega_c}$ for assumed pure shower meteors	$\log \frac{\omega}{\omega_c}$ for assumed stray meteors	Apparent error dispersion in $\log \frac{\omega}{\omega_c}$
Arizona, rocking mirror	—33; —26; —24; —24; —23; —22; —18; —18; —17; —16; —16; —16; —16; —15; —14; —13; —12; —10; —10; —8; —4; —3; —3; —3; —2; 0; 0; 2; 2; 2; 3; 4; 4; 4; 6; 7; 7; 7; 7; 7; 9; 9; 10; 11; 12; 14; 18; 18; 20; 22; 24; 24; 28; 31; 37; 38; 52. (n = 57)	—50; —39; —23; —10; —8; —8; 13; 18; 33; 54; 55; 56. (n_s = 12)	±17.7
Arizona, estimates	—36; —30; —24; —24; —21; —19; —19; —17; —17; —12; —9; —8; —7; —6; —5; —4; —4; —4; —1; 0; 0; 2; 2; 3; 3; 3; 3; 5; 10; 11; 12; 14; 15; 20; 20; 27; 44. (n = 37)	—27; —25; —15; —7; 18; 21; 22; 34. (n_s = 8)	±16.0
Tartu, rocking mirror	—25; —20; —16; —16; —16; —15; —14; —12; —10; —9; —8; —6; —5; —5; —3; —3; —2; —2; —2; —2; —1; —1; 0; 1; 1; 2; 2; 3; 3; 3; 5; 6; 7; 7; 7; 8; 9; 10; 14; 14; 15; 24. (n = 42)	—25; —21; —19; —3; 9; 12; 17; 20; 20; 24; 25. (n_s = 11)	±10.2
Tartu, estimates	—26; —16; —12; —10; —6; —6; —5; —5; —3; —3; —1; —1; 0; 1; 2; 4; 4; 5; 5; 7; 7; 8; 12; 12; 16; 17; 23; 39. (n = 28)	—22; —6; 10; 12; 15; 57; 69. (n_s = 7)	±12.9

Table VIII.

Most Probable Error Frequencies for Different Directions of motion, combined observations of E. Ö.

	Deviation in log T (unit = $^1/_4$ log 2)					
	0	± 1	± 2	± 3	± 4	± 5
	Frequency					
P = 15°; 345° sporadic	0.28	0.20	0.09	0.04	0.02	0.01
„ „ shower	....	....	....	....	....	....
P = 45°; 315° sporadic	0.32	0.21	0.08	0.03	0.01	0.01
„ „ shower	....	....	....	....	....	....
P = 75°; 285° sporadic	0.30	0.20	0.09	0.04	0.01	0.01
„ „ shower	0.22	0.18	0.11	0.06	0.03	0.01
P = 105°; 255° sporadic	0.28	0.19	0.10	0.04	0.02	0.01
„ „ shower	0.28	0.19	0.10	0.04	0.02	0.01
P = 135°; 225° sporadic	0.30	0.20	0.09	0.04	0.01	0.01
„ „ shower	0.40	0.22	0.06	0.01	0.01	0.00
P = 165°; 195° sporadic	0.34	0.20	0.08	0.03	0.01	0.01
„ „ shower	0.28	0.20	0.09	0.04	0.02	0.01

above lead to the laws of observational errors as represented by Table VIII.

6. *Statistical Discussion.* The probable error of the Tartu rocking mirror observations (with observed oscillations) is found to be so small that these observations seem to be much superior as compared with the Arizona observations; it may be interesting to inquire whether this more accurate material differs in its statistical composition from the less accurate former data. The distribution of T_0, the heliocentric tangential velocities, is compared in Table IX; the accidental error for the Tartu series being small, the observed distribution without correcting it for observational error dispersion is quoted *), whereas the combined Arizona data are corrected for error dispersion by a provisional method (*cf.* [1], Section 3, where the data given in the present Table IX appear as an intermediate step and are not published). As appears from Table IX, the two sets if reduced to the same total number reveal a closely similar distribution, within the

*) The influence of the accidental error dispersion is proportional to the square of the mean error and rapidly decreases with the decreasing error.

Table IX.

Comparison of the Distribution of Heliocentric Tangential Velocities (T_0) for Arizona (three observes, *cf.* [1]) and Tartu (E. Ö.) Rocking Mirror Observations.

T_0 km/sec	Arizona [1]	Same, divided by 6.16	Tartu rocking mirror
	Number of Meteors		
< 15	71	11.5	20
15 — 17	33	5.4	6
18 — 21	57	9.3	5
22 — 25	71	11.5	12
26 — 29	74	12.0	15
30 — 35	218	35.5	26
36 — 42	291	47.3	45
43 — 50	229	37.2	33
51 — 59	189	30.7	30
60 — 71	112	18.2	24
72 — 84	51	8.3	5
85 — 100	11	1.8	6
> 100	29	4.7	6
All	1436	(233.4)	233

natural uncertainty $\pm\sqrt{n}$; even the slight excess of very high, and very small velocities, and the slight deficiency of medium velocities revealed by the Tartu set would doubtlessly disappear after the correction for accidental error dispersion. Thus, from the standpoint of the distribution of heliocentric velocities without regard to direction, the Tartu observations of E. Ö. do not show a perceptible systematic difference as compared with the already published Arizona combined data of three observers; the similarity persists in spite of the considerable difference in geographic latitude between the two observing stations.

The above refers to sets of observations obtained by the rocking mirror procedure; Table IX establishes the fact that the particular method of observation with the rocking mirror and the individual differences between the observers do not seem to have a perceptible influence upon the observed distribution of velocities. Table X shows how much of a difference in the statistical data may be revealed by the method of estimated durations, as compared with the rocking mirror observations. Both sets are

Table X.

Comparison of the Distribution of Recorded Geocentric Tangential Velocities (T) for Rocking Mirror Observations and Estimates by E. Ö., Tartu and Arizona Combined.

T km/sec	Rocking mirror	Same, divided by 1.88	Estimates
	Numbers of meteors		
0.0	0	0.0	4
7.5	1	0.5	0
8.9	3	1.6	2
10.6	4	2.1	4
12.6	2	1.1	8
15.0	17	9.1	4
17.9	38	20.2	21
21.2	43	22.8	12
25.2	34	18.1	20
30.0	46	24.5	26
35.8	47	25.0	28
42.4	51	27.2	27
50.4	49	26.1	28
60.0	63	33.5	26
71.6	37	19.7	27
84.8	25	13.3	17
101	19	10.1	11
120	12	6.4	3
144	21	11.2	5
(∞)			
All	512	(272.5)	273

uncorrected for accidental error dispersion, but are well comparable owing to the small difference between the mean errors (*cf.* preceding section). The comparison indicates a general, rather close similarity of the relative distribution of observed velocities; the estimates yield definitely a somewhat larger frequency of very small velocities, and perhaps a deficiency of very large velocities; the difference, however, is so slight that it cannot have a considerable influence upon the concluded distribution of space velocities. The difference must be attributed to the combined effect of the $m\omega$-selection and the specific selection of E. Ö. (*cf.* [1], Section 2); the character of the difference corresponds to the $m\omega$-selection which evidently is the more important one of the two. The smallness of the effect of selection revealed by Table X must be to some extent ascribed to the fact that the statistics refer to the linear velocity, T, whereas the selection depends directly upon the apparent angular velocity, ω; in the transition from ω to T, the variable factor sec$z$ effaces partly the original effect of selection. On the other hand, it is only the influence of selection upon linear, not upon angular velocity we are interested in. Thus, the data of Table X remove a source of uncertainty which we had to admit in former researches because of the lack of a method of testing (*cf.*[1]); rocking mirror observations seem to represent a selection which but slightly differs from the general selection in ordinary observations of meteors.

On the other hand, the possibility that the $m\omega$-selection may be present in general observations of meteors must not be overlooked; slow faint meteors may remain more often unnoticed by the observer than the fast ones because at side vision such a faint and slow object among surrounding fixed stars does not sufficiently attract the attention of the observer. In such a case it would be difficult to draw conclusions regarding the correlation of velocity and magnitude, even from the present complete data freed from the specific selection of the rocking mirror. The question was re-examined on the basis of the Arizona data (*cf.* [1], Section 2); it was found that the coefficient of perception is represented well by a product of two factors, a selection factor in magnitude independent of velocity, and a selection factor in angular velocity independent of magnitude, the evidence for a residual $m\omega$-selection being negative; allowing for the statistical uncertainty of the data (Table III in [1]), it is improbable that the

Table XI.

Distribution of *T*, the Observed Tangential Velocity, in different Directions, for E. Ö. (Tartu + Arizona) as compared with the Combined Observations of R. W. + D. H. (Arizona).

T km/sec	P = 15° + 345°			P = 45° + 315°			P = 75° + 285°		
	R.W.+D.H.	R.W.+D.H. / 2.36	E. Ö.	R.W.+D.H.	R.W.+D.H. / 1.49	E. Ö.	R.W.+D.H.	R.W.+D.H. / 1.76	E. Ö.
0.0									
	0	0.0	1	0	0.0	1	4	2.3	1
7.5									
	2	0.8	1	5	3.4	3	6	3.4	1
10.6									
	7	3.0	3	9	6.0	3	18	10.2	7
15.0									
	15	6.4	9	12	8.1	13	35	19.9	20
21.2									
	12	5.1	*1	18	12.1	6	37	21.0	31
30.0									
	10	4.2	4	12	8.1	8	50	28.4	29
42.4									
	6	2.5	2	11	7.4	10	25	14.2	13
60.0									
	6	2.5	0	7	4.7	7	28	15.9	13
84.8									
	1	0.4	3	0	0.0	0	8	4.6	4
120									
	0	0.0	1	2	1.3	0	0	0.0	1
∞									
All	59	(24.9)	25	76	(51.1)	51	211	(119.9)	120
0.0									
	..	0.8	2	..	3.4	4	..	5.7	2
10.6									
	..	9.4	12	..	14.1	16	..	30.1	27
21.2									
	..	9.3	5	..	20.2	14	..	49.4	60
42.4									
	..	5.0	2	..	12.1	17	..	30.1	26
84.8									
	..	0.4	4	..	1.3	0	..	4.6	5
∞									

$m\omega$-selection produces a variation in the coefficient of perception as large as five per cent, within the limits of apparent magnitude 1.0 and 4.0, and of angular velocity from five to forty degrees per second; for statistical purposes such a small variation, if it exists

Table XI. Continued.

T km/sec	P = 105° + 255°			P = 135° + 225°			P = 165° + 195°		
	R.W.+D.H.	R.W.+D.H. / 1.395	E. Ö.	R.W.+D.H.	R.W.+D.H. / 1.72	E. Ö.	R.W.+D.H.	R.W.+D.H. / 1.172	E. Ö.
0.0									
	1	0.7	0	0	0.0	0	0	0.0	1
7.5									
	3	1.8	1	1	0.6	0	0	0.0	0
10.6									
	11	7.9	*2	5	2.9	2	5	4.3	1
15.0									
	46	33.0	21	20	11.7	10	14	11.9	7
21.2									
	57	40.9	48	34	19.8	12	29	24.7	*11
30.0									
	68	48.8	41	53	30.9	26	61	52.0	39
42.4									
	43	30.8	41	55	32.0	35	79	67.4	54
60.0									
	28	20.2	23	53	30.9	41	73	62.3	69
84.8									
	8	5.8	11	20	11.7	12	26	22.2	*42
120									
	0	0.0	2	6	3.5	6	12	10.2	**31
∞									
All	265	(189.9)	190	247	(144.0)	144	299	(255.0)	255
0.0									
	...	2.5	1	...	0.6	0	...	0.0	1
10.6									
	...	40.9	*23	...	14.6	12	...	16.2	8
21.2									
	...	89.7	89	...	50.7	38	...	76.7	*50
42.4									
	...	51.0	64	...	62.9	76	...	129.7	123
84.8									
	...	5.8	13	...	15.2	18	...	32.4	**73
∞									

at all, is negligible, especially when the statistics refer to zenithal magnitudes and linear velocities, instead of apparent magnitudes and angular velocities (*cf.* also [1], Section 10, where however the selection must have been more conspicuous than for the present data, on account of the selectivity of the rocking mirror observations which was especially pronounced for the Arizona observers).

Table XI contains a comparison of the combined observations of E. Ö. with those of the two Arizona observers, R. W. and D. H.; the table refers to the observed geocentric velocities, uncorrected for error dispersion; the comparison is made separately in different apical directions, attention being paid only to the absolute value of the angle P; the mean value of P for each sector is cited, instead of the limits; thus, $P = 45^0 + 315^0$ means the combination of $P = 30^0 \ldots 59^0$ and $P = 300^0 \ldots 329^0$. In the table three columns correspond to each P-group; the first column gives the number recorded by the two Arizona observers (n_1); the second column gives the same divided by a ratio (k) which makes the total equal to the total recorded by E. Ö.; the third column contains the number recorded by E. Ö. (n_2), rocking mirror observations and estimates for Tartu and Arizona being joined together. Thus, the figures of the second and third columns are adjusted for direct comparison; in the comparison it must be taken into account that the natural uncertainty of a difference $\frac{n_1}{k} - n_2$ is equal to $\pm \sqrt{\frac{n_1}{k^2} + n_2}$ (standard deviation). The table consists of two sections; the upper portion, with the velocity intervals spaced in the ratio $\sqrt{2} : 1$, and the lower portion spaced in the ratio $2 : 1$. The cases when the difference between the figures of the second and third column equals from two to three times the standard deviation (probability 0.042) are marked with single asterisks; those exceeding the triple standard deviation (probability 0.0027) — with double asterisks.

Both portions of Table XI indicate concordantly a great similarity of the two sets of velocity observations; the differences, with one exception, are all reasonably within the limits of the natural uncertainty; thus, the relative frequency of velocities recorded in a given direction by R. W. and D. H. with the rocking mirror agrees very well with the frequency found by E. Ö. from rocking mirror observations and estimates; the agreement is the

more remarkable because the selectivity of the velocity records of R. W. and D. H. was very high (one velocity for five meteors seen), whereas the present material of E. Ö. represents complete records and is practically free from this sort of selectivity.

The only real difference between the two sets refers to $P = 165^0 + 195^0$, where E. Ö. has 73 velocities exceeding 84.8 km/sec, against 32.4 expected from the data of R. W. + D. H. The probability of an accidental difference of this size is only 6.10^{-5}. The excess of the high velocities of E. Ö. appears in his different sets of observations as follows:

Set of observations, E. Ö.	Rocking mirror, Arizona	Estimates, Arizona	Rocking mirror, Tartu	Estimates, Tartu
Number recorded by E. Ö.	35	10	17	11
Number expected from R. W. + D. H.	10.5	4.7	10.8	6.4
Excess	+24.5	+5.3	+6.2	+4.6

It appears that the excess is chiefly due to the Arizona rocking mirror series of E. Ö.; this case has already been discussed (*cf.* [1], Sections 4 and 9), the excess being attributed to two possible causes — the effect of observational selection, and the activity of a cosmic stream of high velocity in October, 1931. The above data seem to indicate that the second cause was the chief one (in October, 1931, estimates of duration were not made, which explains the absence of the large excess in the Arizona estimates which were made only in November). At the same time, the persistence of a moderate excess in the three remaining series of E. Ö. indicates that observational selection is also partly responsible for it.

The general conclusion which may be drawn from the above discussion is that effects of selection and systematic influences of the particular method, as well as the personality of the observer are found to have little influence upon the statistics of meteor velocities; in any case, for the present observations of the writer, consisting of rocking mirror observations supplemented by the estimates of duration, the effects of specific selection must be negligible. The observational material referring to meteor velocities appears to be well established; little new can be expected

from observations continued along the same lines as before. If there exists some uncertainty in the conclusions, the method of interpretation is responsible for that. Namely, in comparison with observational selection, a much greater effect upon the final conclusions may be exercised by the hypotheses upon which the distribution of space velocities is derived; these hypotheses refer to the observational error function, and to the distribution of the projection ratios (tangential velocity: space velocity). The larger the assumed observational error dispersion, the smaller is the resulting spread in meteor velocities and the smaller the relative number of high velocities concluded. The influence of the assumed law of projection ratios is different: the greater the spread in the projection ratios, the higher is the mean velocity and the larger the fraction of high velocities found. By assuming certain limiting cases for these hypothetical frequency functions, the probable extreme limits to our knowledge of the true distribution of meteor velocities may be outlined.

Without taking recourse to hypotheses, the fundamental problem of the difference between sporadic and shower meteors can be treated qualitatively, on the basis of the uncorrected distribution of the observational records. Table XII contains the comparison referred to the heliocentric projected velocities uncorrected for observational error dispersion. The ratio of the number of sporadic to shower meteors is given in each third column of a subsection of the table; the ratio generally increases toward higher velocities, indicating that high velocities are more frequent among sporadic meteors than among the supposed shower meteors; most clearly this fact is shown by the last section of the table, referring to the combined observations of E. Ö.

The recorded velocities of the shower meteors may exceed the parabolic limit, 42 km/sec, for the following reasons: 1) the observational error dispersion; 2) the presence of stray hyperbolic meteors among the apparent members of a shower; 3) the possibility for some of the showers to have hyperbolic velocities. The first cause is probably the most important one. To judge upon the second cause, the theoretically estimated numbers of stray meteors are given at the foot of Table XII; these figures are comparatively small, but for some reasons they may be underestimated (*cf.* [1], Section 1). The third cause may perhaps be re-

Table XII.

Comparison of the Apparent Distribution of Heliocentric Tangential Velocities for Sporadic and Shower Meteors (E. Ö.).

T_0 km/sec	$P = 0^0 \ldots 59^0$ and $300^0 \ldots 359^0$ (antapex directions)				$P = 60^0 \ldots 119^0$ and $240^0 \ldots 299^0$ (transversal directions)					
	Tartu		Arizona		Tartu			Arizona		
	sp.	sh.	sp.	sh.	sp.	sh.	ratio	sp.	sh.	ratio
0 ... 14	0	0	0	0	0	0	...	0	0	...
15 ... 21	0	0	0	0	0	0	...	0	0	...
22 ... 29	3	0	1	0	5	2	2.5	11	1	11.0
30 ... 42	8	0	7	0	43	12	3.6	57	29	2.0
43 ... 59	15	0	11	1	35	4	8.8	35	15	2.3
60 ... 84	8	1	10	0	11	3		16	9	1.8
85 ... 119	3	0	5	0	4	0	5.3	12	2	3.3
⩾ 120	1	0	2	0	1	0		1	2	
All	38	1	36	1	99	21	4.7	132	58	2.3
Stray expected	...	1	...	1	...	5	...	...	12	...

T_0 km/sec	$P = 120^0 \ldots 239^0$ (apex directions)						All directions Tartu + Arizona		
	Tartu			Arizona					
	sp.	sh.	ratio	sp.	sh.	ratio	sp.	sh.	ratio
0 ... 14	15	15	1.0	11	5	2.2	26	20	1.3
15 ... 21	11	8	1.4	16	6	2.7	27	14	1.9
22 ... 29	21	13	1.6	16	8	2.0	57	24	2.4
30 ... 42	30	15	2.0	17	9	1.9	162	65	2.5
43 ... 59	41	10	4.1	24	14	1.7	161	44	3.7
60 ... 84	22	4	5.5	15	7	2.1	82	24	3.4
85 ... 119	9	0	14.0	11	2	4.2	44	4	6.2
⩾ 120	5	1		14	4		24	7	
All	154	66	2.3	124	55	2.3	583	202	2.9
Stray expected	...	12	...	...	7	...	...	38	...

sponsible for the weakness of the correlation of the "ratio" of sporadic to shower meteors with velocity in the second section of Table XII, the "transversal directions", Arizona series, in which the correlation is practically absent; the shower meteors of this group belong all to radiants near $\alpha = 40^0$—60^0, $\delta = +20^0$, active

the end of October and the beginning of November; these may be partly in connection with Hoffmeister's Taurus stream, in which case hyperbolic velocities of many true shower meteors may occur as a rule; of course, this is only a possibility which needs special confirmation; owing to the small number of meteors, the absence of the correlation in this particular case may be purely accidental. The Tartu observations give a much more persistent and strong correlation with velocity of the ratio (sporadic: shower) than the Arizona observations do; the smaller accidental error of the Tartu series is apparently responsible for that. For the apex directions, Arizona, the ratio of the numbers of sporadic to shower meteors shows a peculiar correlation: the ratio attains a minimum at medium velocities, increasing toward both large and small velocities; this may be interpreted as an indication of the presence of short period, low velocity solar meteors in the sporadic group, in addition to the high velocity hyperbolic meteors (*cf.*[1], Section 8).

Table XIII.

Heliocentric Tangential Velocity (T_0) and Zenithal Magnitude (m_z), Sporadic Meteors (E. Ö.).

T_0 km/sec		⩽ 35	35 ... 42	43...50	51...59	60...71	⩾ 72	All
$\overline{m}_z$								
—1.0	*n*	17	15	5	7	8	10	62
	%	28	24	8	11	13	16	100
+1.5	*n*	53	30	33	26	20	38	200
	%	26	15	17	13	10	19	100
+2.5	*n*	64	37	34	26	9	32	202
	%	32	18	17	13	4	16	100
+3.6	*n*	*32(29)	*30(27)	17	13	11	22	125
	%	26	24	14	10	9	17	100
All	*n*	*166	*112	89	72	48	102	*589
	%	28	19	15	12	8	18	100

In the same manner, namely from the distribution of recorded velocities, the correlation of velocity and luminosity may be studied. Table XIII contains the corresponding data. The recorded velocities, as well as the recorded zenithal magnitudes are here used; on account of error dispersion the true mean values of m_z must exhibit a smaller range than the mean recorded values

quoted in the table (*cf.*[7], Section 6). The present data of E. Ö. are free from the $m\omega$-selection except for the period from October 6 to 22, 1931, when estimates of duration were not made at all; on the basis of certain former data (*cf.* [1], Table III) it was found that the selection influenced appreciably only the magnitude group $m^z = +3.6$ for $T_0 \leqslant 42$ km/sec; the effect of selection was estimated and the data for the October lunation corrected for it; the corrected figures (only two cases) are marked in Table XIII with asterisks, the uncorrected figures being given in parentheses. As can be seen from the table, the correction for $m\omega$-selection is unimportant, amounting to only six units or one per cent of the total number; so small a correction might have been neglected without changing perceptibly the results, which circumstance increases our confidence in the objectiveness of the data of Table XIII. As to the conclusion, the similarity in the distribution of velocities within the different magnitude classes of the table is quite close; thus, within the range of luminosity covered by our statistics no systematic change in the distribution of velocities depending upon luminosity can be traced. The conclusion differs from the combined Arizona data [1] which indicated a sensible deficiency of high velocities in the brightest magnitude class. The question of the peculiar distribution of velocities for very bright meteors is thus still open; whereas the present material is free from $m\omega$-selection, the Arizona data are more numerous (2.5 times more meteors in the brightest magnitude class) and more uniformly distributed over the whole year; therefore at present we cannot decide in favour of either conclusion.

The above-mentioned discordance is practically of little importance and does not influence perceptibly our former conclusion that the direct observational data recorded by different observers in Arizona are statistically similar to the present data obtained by the writer; therefore, with the same method of reduction both observational series should yield more or less similar results; in other words, the present data, being apparently more accurate than the former ones, still only confirm the results arrived at in the preceding publication (*cf.* [1]), if the same assumptions with respect to the laws of observational and cosmic errors are made. It appears thus unnecessary to apply in full the complicated method of discussion to the present material; on the other hand, by a variation of the basic assumptions we try below to estimate the

range of uncertainty produced by these assumptions in our final results.

The uncertainty in the observational error dispersion may be studied on the basis of the two extreme cases of the law of observational errors: the "maximum error hypothesis" as represented by Table VI, and the "most probable error hypothesis" represented by Table VIII. The third case, the "minimum error hypothesis" which assumes the observational error to be zero is obviously of little interest and is not further considered here (in this case the true distribution of projected velocities is identical with the observed one). The correction for error dispersion was made separately for each sector of the apical direction of motion, the method being described in [1], Section 5. The result is given in Table XIV; the four columns corresponding to a given sector P contain: the observed distribution; the smoothed observed distribution; the distribution corrected with the law of errors represented by the last column of Table VI; the distribution corrected with the law of errors represented by Table VIII. The table refers to sporadic meteors only. The difference between the cases a and b may give an idea of the maximum degree of uncertainty produced by the inaccurate knowledge of the observational error function; whereas for the antapex directions the difference between the two solutions is comparatively small, for the apex directions the difference is more considerable, case a yielding as a rule a smaller number of very small and very large velocities. The bearing of this difference on cosmic problems is more clearly revealed by the distribution of projected heliocentric velocities as given in Table XV; this table is based upon the data of Table XIV, which were redistributed according to the heliocentric limits of velocity computed according to the formula

$$T_0^2 = T^2 + T_g^2 + 2\, TT_g \cos P \quad . \quad . \quad . \quad . \quad (15);$$

the mean value of $T_g = 27.8$ km/sec. was assumed; the value was found to be the actual mean projected orbital velocity of the earth and was practically independent of P. For P the mean values of each sector as printed in the heading of Table XIV were used.

From Table XV we infer that the concluded frequency of heliocentric velocities does not much depend upon the assumed

Table XIV.

Correction for Observational Error Dispersion of the Distribution of Geocentric Tangential Velocities (E. Ö., Tartu + Arizona).

Sporadic Meteors.

a = distribution corrected on the basis of the "maximum error hypothesis";

b = distribution corrected on the basis of the "most probable error hypothesis".

T km/sec	$P = 15^0$ and 345^0				$P = 45^0$ and 315^0				$P = 75^0$ and 285^0			
	obs.	smooth.	*a* corr. III	*b* corr. III	obs.	smooth.	*a* corr. III	*b* corr. III	obs.	smooth.	*a* corr. III	*b* corr. III
0.0												
	1	0.6	0.2	0.5	1	1.0	0.2	0.6	1	0.9	0.4	0.5
7.5												
	0	0.4	0.0	0.0	1	0.9	0.5	0.8	0	0.9	0.4	0.8
8.9												
	1	0.7	0.0	0.0	2	1.3	0.1	0.7	1	1.4	0.3	0.7
10.6												
	1	1.3	0.0	0.6	1	2.1	0.8	1.5	4	2.4	0.7	1.6
12.6												
	2	2.5	3.4	3.0	2	3.4	3.6	3.0	2	3.8	0.9	2.1
15.0												
	5	3.5	6.4	5.5	5	5.2	8.8	7.1	4	6.3	4.1	4.9
17.9												
	4	3.1	5.0	4.1	8	5.4	9.0	7.3	14	9.8	10.5	9.8
21.2												
	0	2.0	1.5	1.5	3	4.0	4.1	3.9	13	13.2	18.9	16.0
25.2												
	1	1.4	0.3	0.6	2	2.8	0.1	1.3	12	14.6	21.4	18.3
30.0												
	2	1.3	0.8	1.1	4	2.9	0.8	1.8	18	13.8	19.9	17.3
35.8												
	2	1.2	1.1	1.2	4	3.5	2.9	3.2	8	10.5	11.7	10.6
42.4												
	1	1.1	1.0	1.1	4	4.5	6.5	5.3	5	7.0	3.9	5.0
50.4												
	1	1.0	0.8	0.9	5	4.8	8.2	6.2	3	5.1	2.5	3.7
60.0												
	0	1.0	1.0	1.0	6	4.3	3.4	6.2	7	3.9	2.5	3.5
71.6												
	0	0.9	0.6	1.0	1	2.3	0.0	0.1	5	3.0	2.5	3.0
84.8												
	1	0.9	1.1	0.9	0	0.6	0.0	0.0	1	2.0	0.4	1.8
101												
	2	0.9	1.4	1.0	0	0.0	0.0	0.0	3	1.3	0.0	1.0
120												
	1	0.8	0.4	1.0	0	0.0	0.0	0.0	0	0.8	0.0	0.4
144												
∞	0	0.4	0.0	0.0	0	0.0	0.0	0.0	0	0.3	0.0	0.0
All	25	=	=	=	49	=	=	=	101	=	=	=

Table XIV. Continued.

T km/sec.	$P = 105^0$ and 255^0				$P = 135^0$ and 225^0				$P = 165^0$ and 195^0			
	obs.	smooth.	*a* corr. III	*b* corr. II	obs.	smooth.	*a* corr. IV	*b* corr. III	obs.	smooth.	*a* corr. IV	*b* corr. IV
0.0												
	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
7.5												
	0	0.0	0.0	0.0	0	0.0	0.0	0.0	0	0.0	0.0	0.0
8.9												
	0	0.0	0.0	0.0	0	0.2	0.0	0.0	0	0.0	0.0	0.0
10.6												
	1	0.5	0.0	0.0	0	0.5	0.0	0.0	0	0.0	0.0	0.0
12.6												
	1	2.1	0.0	0.0	2	1.2	0.0	0.0	0	0.4	0.0	0.0
15.0												
	4	6.0	0.0	1.8	1	2.8	0.0	1.4	1	1.0	0.0	0.2
17.9												
	12	10.6	9.0	11.9	8	5.5	8.3	7.9	4	2.2	0.0	1.7
21.2												
	15	13.8	19.5	16.3	5	6.0	9.1	7.1	4	3.7	3.1	3.5
25.2												
	15	15.4	20.3	17.8	6	6.0	4.7	5.1	4	5.4	4.1	4.3
30.0												
	15	15.6	19.3	17.2	6	6.6	1.5	4.1	6	7.8	6.0	7.0
35.8												
	12	15.1	18.0	16.6	9	8.8	3.9	6.7	15	10.8	8.7	9.8
42.4												
	18	13.5	15.1	14.4	14	12.1	11.6	11.3	11	14.4	13.1	13.7
50.4												
	11	11.4	12.1	11.7	11	16.3	26.2	20.5	18	18.4	21.0	19.0
60.0												
	8	9.1	9.3	8.9	23	18.0	35.7	26.2	21	22.0	31.1	26.3
71.6												
	8	7.0	7.1	7.0	11	13.4	11.0	16.6	25	22.4	33.3	26.7
84.8												
	6	4.8	0.3	4.5	8	6.5	0.0	2.2	19	19.7	27.4	23.6
101												
	3	2.6	0.0	1.6	3	3.4	0.0	0.5	13	13.9	12.7	12.7
120												
	0	1.2	0.0	0.0	1	1.9	0.0	0.4	9	9.4	5.5	7.4
144												
	1	1.3	0.0	0.3	4	2.8	0.0	2.0	16	14.5	0.0	10.1
∞												
All	130	=	=	=	112	=	=	=	166	=	=	=

Table XV.

Distribution of Heliocentric Tangential Velocities (T_0) corrected for Observational Error Dispersion.

Sporadic Meteors.

Cases *a* and *b* as in Table XIV.

T_0 km/sec	$P = 15^0$ and 345^0		$P = 45^0$ and 315^0		$P = 75^0$ and 285^0		$P = 105^0$ and 255^0		$P = 135^0$ and 225^0		$P = 165^0$ and 195^0		All directions	
	a	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*	*a*	*b*
0.0														
	0	0	0	0	0	0	0	0	0	0	18.7	22.9	18.7	22.9
15.0														
	0	0	0	0	0	0	0	0	0	0	4.6	5.1	4.6	5.1
17.9														
	0	0	0	0	0	0	0	0	19.6	18.6	5.8	6.0	25.4	24.6
21.2														
	0	0	0	0	0	0	0	0	4.0	6.8	7.2	7.3	11.2	14.1
25.2														
	0.1	0.2	0.1	0.2	0.3	0.4	7.1	11.2	3.9	6.8	10.9	9.9	22.4	28.7
30.0														
	0.1	0.3	0.7	1.8	4.4	7.6	44.6	39.2	10.3	10.2	14.1	12.5	74.2	71.6
35.8														
	3.3	3.5	13.2	11.7	33.1	29.7	27.7	25.1	19.6	15.6	18.0	15.2	114.9	100.8
42.4														
	12.2	10.4	13.1	11.6	38.4	33.2	20.6	19.4	26.5	19.8	20.8	17.0	131.6	111.4
50.4														
	1.5	1.9	1.5	3.3	14.9	14.1	14.0	13.6	21.1	18.6	23.1	18.7	76.1	70.2
60.0														
	1.8	2.1	7.8	7.1	4.3	5.9	9.7	9.2	7.0	11.1	19.7	17.0	50.3	52.4
71.6														
	1.3	1.5	10.0	8.6	3.0	4.2	6.1	6.7	0	1.7	11.8	11.1	32.2	33.8
84.8														
	1.3	1.4	2.6	4.7	2.3	3.2	0.2	4.0	0	0.4	7.6	8.2	14.0	21.9
101														
	1.1	1.2	0	0	0.3	1.7	0	1.3	0	0.3	3.7	5.4	5.1	9.9
120														
	1.7	1.3	0	0	0	0.8	0	0.0	0	0.4	0	3.6	1.7	6.1
144														
	0.6	1.2	0	0	0	0.2	0	0.3	0	1.7	0	6.1	0.6	9.5
∞														
All	25	=	49	=	101	=	130	=	112	=	166	=	583	=

law of observational errors; even the two extreme cases, *a* and *b*, give distributions which are very similar in their general features. Only in the case of very large velocities the assumed law of errors considerably influences the results; for $T_0 > 120$ the difference between the two hypotheses is so large that with case *a* the reality of heliocentric velocities exceeding 120 km/sec becomes doubtful, in spite of the not inconsiderable number of such velocities resulting in case *b*. Although case *a*, the "maximum error hypothesis", doubtlessly exaggerates the observational error dispersion, so that the frequency of $T_0 > 120$ must be larger than in Table XV, *a*, the frequency is so small that we feel justified to look for independent proof of these large velocities before we accept their reality as established. Except for that, the similarity between cases *a* and *b* is close; thus, the relative frequency of the projected heliocentric velocities exceeding 42.4 km/sec, the parabolic limit, is 53.4 per cent in case *a*, and 54.1 per cent in case *b*; these, practically identical figures represent at the same time the minimum frequency of hyperbolic objects among sporadic meteors; this is a minimum, because the space velocities may exceed, never fall below the projected velocities to which the above figures refer.

Table XVI.

Law of Projection Ratios for Geocentric Velocities,

All Directions.

I = semi-empirical law according to [1], $\overline{\sin \lambda} = 0.785$.
II = random distribution $\overline{\sin \lambda} = 0.785$.

sin λ	I	II	sin λ	I	II	sin λ	I	II
1.000			0.421			0.177		
	0.530	0.540		0.030	0.028		0.005	0.005
0.842			0.354			0.148		
	0.167	0.167		0.020	0.020		0.003	0.004
0.707			0.297			0.125		
	0.096	0.097		0.014	0.013		0.002	0.003
0.594			0.250			0.105		
	0.069	0.062		0.010	0.010		0.005	0.004
0.500			0.210			0.000		
	0.042	0.041		0.007	0.006			
0.421			0.177			Sum	1.000	1.000

With that we approach the question of the influence of the law of projection ratios upon the concluded distribution of space velocities. The true frequency function of projection ratios is unknown in the present case, but can be derived upon certain assumptions. In [1] the frequency of geocentric projection ratios in separate apical directions was derived from the observed total frequency of meteors in different directions, supplemented by the assumption of certain smooth laws of variation of the radiant density with the distance from the apex and with the declination (*cf.* [1], Table XVI); the semi-empirical law thus obtained should contain very little hypothetical element, as the assumed laws of radiant density are used only for interpolation between observed figures. In the present case we want a law of projection ratios for all directions combined; from Table XV of [1] the law is found as given in the present Table XVI. It is surprising to find the law almost identical with a random distribution, which is given for comparison.

The distribution refers to geocentric velocities, whereas we are here concerned with heliocentric velocities; the direct calculation of this distribution is rather complicated, but we make use of an indirect, practically equally accurate method. From Table XVI of [1], as well as from the present Table XVI and from Table II of [4] we infer that, for the smooth functions considered, their properties are well determined by one single parameter, namely by the average value of the projection ratio, $\sin \lambda$. By using the simplification applied throughout in [1], i. e. by assuming a whole sector of P to be concentrated in its centre of radiation, the differential changes of $\sin \lambda$ at the transition from geocentric to heliocentric motion can be calculated, assuming these equal to the differential changes of $\sin \lambda$ of the centre of radiation; the observed frequency of heliocentric velocities as found in [1] was used as weight in the calculation. In such a manner $\sin \lambda$ was calculated as follows, from the data of Table XVIII of [1], as compared with the data at the bottom of Table XV of [1].

W km/sec	<36	36—50	>50	All
$\overline{\sin \lambda}$, geocentric	0.803	0.792	0.750	0.785
$\overline{\sin \lambda}$, heliocentric	0.745	0.777	0.749	0.759

Here W is the heliocentric space velocity.

The mean heliocentric projection ratio for the observed meteors is smaller than the geocentric one because more meteors come from the apex where the heliocentric radiants are displaced mostly toward the region of observation (north pole).

The distributions corresponding to the above quoted values of $\overline{\sin \lambda}$ are chosen from Table XVI of [1] and are given in columns A, B, and C of the present Table XVII; these data represent thus the semi-empirically derived distributions of the projection ratios for different velocity classes of the 1436 velocities observed in Arizona (*cf.* [1]). The concentration of the distribution of $\sin \lambda$ for medium velocities (about the parabolic value $W = 42$) is found to be greater than for the hyperbolic and the elliptical velocities (the concentration can be measured by the relative frequency of large projection ratios, $\sin \lambda = 0.842 - 1.000$, also by the mean value of $\sin \lambda$); this circumstance was partly anticipated in an early publication (*cf.* [4], Table II) from purely theoretical considerations; the distributions conjectured there are numerically in satisfactory agreement with our present results.

The explanation is given by the fact that the radiants of the solar meteors are more strongly concentrated toward the ecliptic, yielding thus a greater number of large distances from the north polar region of observation. This explanation is strongly supported by the data of column D which contain the observed distribution of $\sin \lambda$ for the 202 shower meteors of E. Ö.; the concentration of the distribution in D is unexpectedly large, indicating that very few shower meteors were observed near their radiants; of course, the small number of radiants to which these 202 meteors were supposed to belong makes the result subject to considerable accidental uncertainty.

The distribution given under D corresponds to geocentric velocities; the heliocentric velocities, as shown above, must show a smaller concentration; further, the sporadic meteors have a smaller concentration than the shower meteors; thus, case D of Table XVII represents a distribution which is doubtlessly more, probably considerably more concentrated than the distribution of projection ratios for the heliocentric velocities of sporadic meteors.

Table XVII.

Frequency of Projection Ratios for Heliocentric Velocities. All Directions.

Sin λ	All Meteors, Arizona			All velocities, E. Ö.	
	A $W > 50$ $W < 36$	B $W = 36-50$	C All velocities	D *) Shower meteors	E Sporadic meteors
1.000					
	0.465	0.523	0.489	0.757	0.418
0.842					
	0.170	0.170	0.170	0.148	0.176
0.707					
	0.106	0.099	0.103	0.040	0.119
0.594					
	0.085	0.071	0.076	0.020	0.091
0.500					
	0.054	0.043	0.050	0.015	0.059
0.421					
	0.035	0.030	0.033	0.010	0.039
0.354					
	0.025	0.019	0.022	0.005	0.026
0.297					
	0.017	0.014	0.017	0.002	0.021
0.250					
	0.013	0.010	0.012	0.002	0.015
0.210					
	0.010	0.007	0.008	0.001	0.010
0.177					
	0.006	0.004	0.006	0	0.008
0.148					
	0.004	0.003	0.004	0	0.005
0.125					
	0.003	0.002	0.003	0	0.004
0.105					
	0.007	0.005	0.007	0	0.009
0.000					
Sum	1.000	1.000	1.000	1.000	1.000

The frequency of projection ratios for sporadic meteors can be computed from the formula

$$f_1 = f_0 + \frac{n_2}{n_1}(f_0 - f_2) \quad . \quad . \quad . \quad . \quad . \quad . \quad (16),$$

*) Refers to geocentric radiants, or velocities.

where f_1 is the frequency for the sporadic, f_2 — for the shower meteors, f_0 — for all meteors, n_1 — the number of sporadic, n_2 — of shower meteors. With $n_1 = 621$, $n_2 = 164$ (after subtracting the probable number of 38 stray objects) for E. Ö., and with f_2 according to column D, f_0 according to column C of Table XVII, the hypothetical frequency of projection ratios of sporadic meteors as given under E of the same table is calculated. The concentration of E is doubtlessly, although probably not very much smaller than the true concentration of $\sin \lambda$ for the sporadic meteors of E. Ö. because of the following causes which act in the same direction: as the 1436 Arizona velocities contain a smaller relative fraction of shower meteors (*cf.* [1]) than the present set of E. Ö., the concentration of C, Table XVII, must be somewhat smaller than the true concentration of the distribution of projection ratios for all meteors of E. Ö.; further, the distribution under D has a greater concentration than the distribution of heliocentric velocities of the shower meteors. Thus, in formula (16) the concentration of f_0 is underestimated, of f_2 — overestimated; as a result, the concentration of f_1 is doubly overestimated.

Hence we are safe in assuming that the unknown true distribution of projection ratios of the heliocentric velocities for the sporadic meteors of E. Ö. is intermediate between cases D and E of Table XVII, probably closer to E than to D. In applying these limiting distributions to the data of the two last columns of Table XV, we obtain altogether four limiting cases for the distribution of heliocentric space velocities which are contained in Table XVIII. The method of the solution for the distribution of space velocities is described in [1], Section 6. The space velocity, W, is represented by discrete values which are supposed to be mean values for the corresponding groups; in the second column of Table XVIII the velocities are given tentatively corrected for the mean effect of zenithal attraction and for the probable ellipticity of the orbits of shower meteors used for standardization (*cf.* [4], p. 5). In judging the data of the table, we have to take into account that case *a* (a large observational error) is less favourable to large and small velocities as compared with *b*, whereas case D (a large concentration of projection ratios) is less favourable to large, and more favourable to small velocities as compared with E. From the table we find that the assumed size

Table XVIII.

Distribution of Heliocentric Space Velocities, Sporadic Meteors, E. Ö.

aD = maximum observational error and maximum concentration of projection ratios;
aE = maximum obs. error and minimum concentration of proj. r.;
bD = probable observational error and maximum concentration of proj. r.;
bE = probable obs. error and minimum concentration of proj. r.

W km/sec		aD	aE	bD	bE
uncorr.	corr.				
⩽15.0	⩽(12)	11	0	16	0
17.9	(15)	0	0	0	0
21.2	(18)	25	0	24	0
25.2	(21)	2	0	5	0
30.0	26	4	0	14	0
35.8	32	64	9	65	17
42.4	39	115	77	100	69
50.4	47	153	188	128	171
60.0	57	86	121	78	104
71.6	69	58	83	59	84
84.8	83	39	62	39	56
101	98	17	28	26	39
120	116	6	10	11	15
144	140	2	4	6	5
⩾ 171	⩾ 166	1	1	12	23
All	...	583	583	583	583
Short period solar	n ($\overline{W}$ ⩽ 32)	106	9	124	17
	% ...	18.2	1.6	21.3	2.9
Long period solar	n ($\overline{W}$ = 39)	115	77	100	69
	% ...	19.7	13.2	17.1	11.8
Hyperbolic	n ($\overline{W}$ ⩾ 47)	362	497	359	497
	%	62.1	85.2	61.6	85.2

of the observational error has little influence upon the number of very small velocities which depends chiefly upon the law of projection ratios; however, this latter but moderately influences

the frequency of very high velocities which is rather sensible to the assumed law of observational errors.

At the bottom of Table XVIII the summary of the distribution for the wider velocity classes is given; it appears that the relative frequency of small velocities, the "short period solar meteors", is very uncertain and depends largely upon the assumed law of projection ratios (which may in this case differ from the laws valid for other velocities); very uncertain is also the frequency of very high hyperbolic velocities, $W \geqslant 116$ km/sec, which may amount to from two to nine per cent. The relative frequency of intermediate velocities, from $W = 39$ to $W = 98$ km/sec, although sensibly influenced by the different hypotheses, does not show variations of fundamental importance and may be considered as satisfactorily established, independently of the assumptions regarding the law of errors and of projection ratios.

7. *Summary.*

a. Rocking mirror observations of meteor velocities were obtained by the writer at Tartu by an improved method; the writer's estimates of duration, as compared with computed durations of the shower meteors, are found to be of a satisfactory accuracy, comparable to the accuracy of the rocking mirror observations. The estimates of duration of the four other chief Arizona observers are found to be unusable.

b. The joint observations of the writer, consisting of 785 velocities determined at Tartu and in Arizona by the rocking mirror method and from estimated durations, are published and discussed. The 583 apparently sporadic meteors are considered separately from the 202 supposed shower meteors which are used for the purpose of standardization.

c. The frequency function of the observational errors in the logarithm of velocity is investigated; two limiting cases for this function are established: the case of maximum observational error dispersion, represented by the distribution of the ratios of observed to computed angular velocities of the shower meteors, none rejected; and the case of the most probable observational error dispersion, derived by rejecting the probable number of stray meteors from the shower meteors.

d. By comparing the different available sets of visual observations of velocities it is found that a similar relative distri-

bution of recorded velocities is obtained, indicating that the effects of selection for the different methods and observers are not considerable. The present more refined observational material is statistically similar to the 1436 Arizona velocities already discussed [1], confirming the latter; it is obvious that both sets if reduced on the same principles must yield very similar results; thus, the results derived from the 1436 Arizona velocities need not be revised unless the basic hypotheses, especially the law of projection ratios can be improved; this can be done only when more accurate individual heights and real paths for the velocity meteors are available (observations with such a purpose in view are in progress, supported by the Estonian Academy of Sciences). Until these data become available, the results obtained in [1] may be considered the most probable ones which can be derived on the basis of the statistical mean heights and adopted laws of observational and cosmical errors.

e. Without any hypothetical assumptions, the direct comparison of the observational records indicates a conspicuous difference in the distribution of velocities for the sporadic and the shower meteors; the sporadic meteors yield a larger relative fraction of high velocities and a higher mean heliocentric velocity, in agreement with their supposed extra-solar origin.

f. From the present observational material, the evidence for a change of velocity with magnitude (sporadic meteors) is negative; in this respect the data differ from those of [1], but the number of very bright meteors which decide the question is much smaller than in Arizona.

g. To get an idea of the influence of the assumed hypotheses upon the final conclusions, the distribution of heliocentric velocities is derived upon certain limiting assumptions regarding the law of errors and of projection ratios; the assumptions are chosen in such a manner that the true conditions must be found somewhere in between. The comparison of the results indicates that the relative frequency of very small ($<$ 35 km/sec) and very high ($>$ 107 km/sec) heliocentric velocities is uncertain, depending largely upon the assumed hypotheses; the relative frequency of intermediate velocities, although depending upon the assumptions, cannot be changed fundamentally by the adopted hypotheses and may be considered as satisfactorily established; these

considerations are important for judging the conclusions arrived at in [1]. It is found that the fraction of hyperbolic meteors among visually observed sporadic meteors lies between 62 and 85 per cent, the higher value being the more probable; the fraction of long period (up to almost parabolic) objects is from 12 to 20 per cent, whereas the fraction of short period (planetary or asteroidal) objects is from 2 to 21.

Tartu,

January 1940.

References.

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Notation.

The notation is practically identical with the notation of [1].