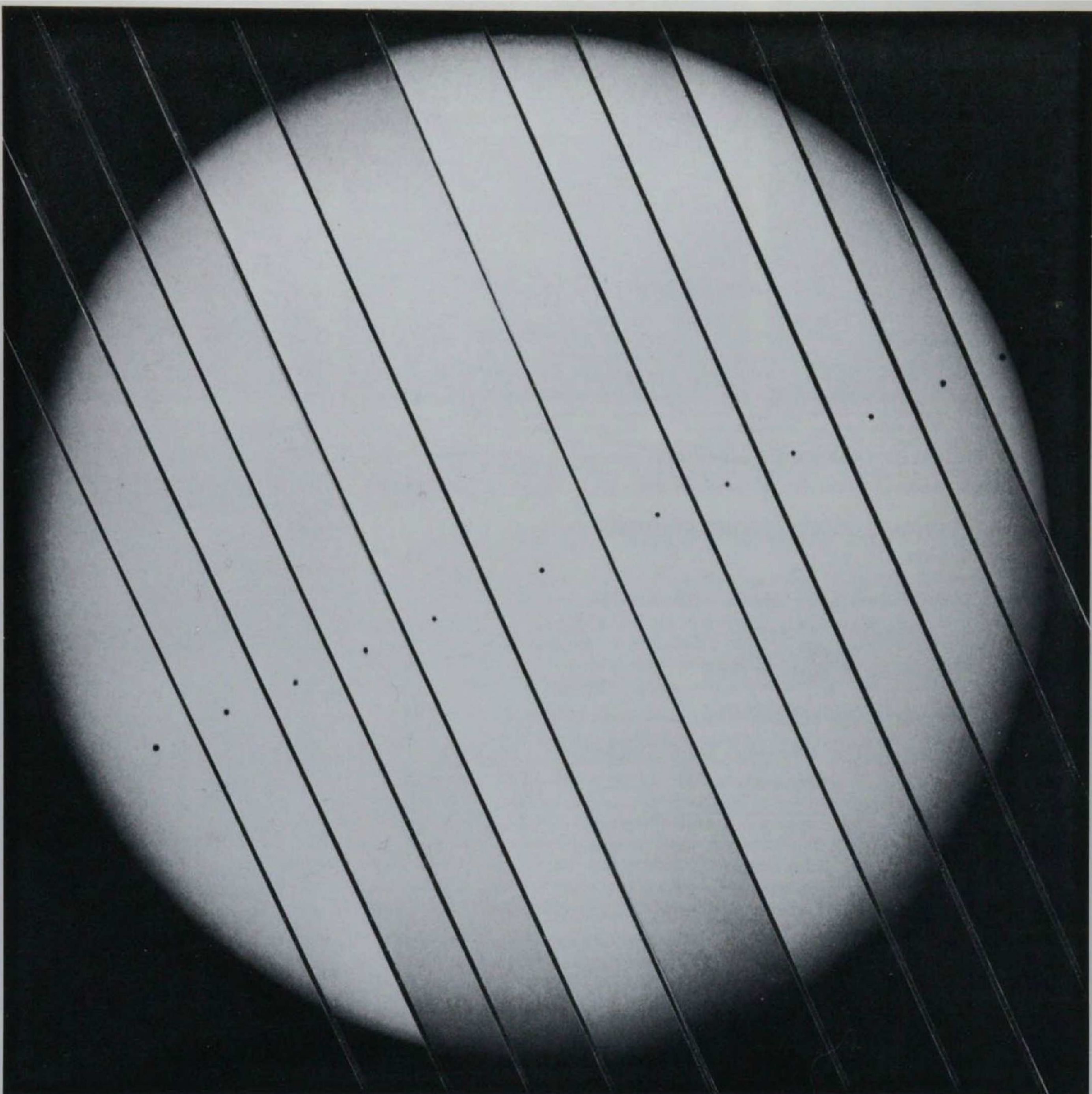


Observers in Europe and Africa could witness the entire transit, as shown in this montage by Gerhart Klaus at Grenchen, Switzerland. The first strip, at lower left, was taken at 8:15 Universal time, the others at 8:40, 9:05, 9:30, 9:55, 10:33, 11:15, 11:40, 12:05, 12:30, 12:55, and 13:13 (roughly three minutes before third contact). Mercury passed very near the center of the sun's disk, here with north at the top. Conspicuous is the absence of sunspots that day. Mr. Klaus used a homemade 4-inch refractor, a green interference filter, and 1/500-second exposures on Gevaert Copex Pan Rapid film.

A Well-Observed Transit of Mercury

JOSEPH ASHBROOK

FOR 5½ HOURS on November 10, 1973, the planet Mercury was observable in small telescopes as a tiny round black dot, crawling slowly westward across the bright face of the sun. Only 14 transits of Mercury occur per century, on the average, and the next is not due until the year 1986.

Not surprisingly, amateurs in many countries turned out to view and photograph the rare phenomenon. Local societies arranged well-attended transit parties, and at many college observatories astronomy students timed contacts and took photographs as a practical exercise. Reports have been received from 11 countries, extending from Mexico to Finland, Sweden, Hungary, and Yugoslavia.

For professional astronomers, the transit of Mercury offered a favorable opportunity to determine the planet's diameter. One modern technique for this is to measure photoelectrically the amount of sunlight transmitted by a small diaphragm in the focal plane of a telescope, first when Mercury and a surrounding ring of sun are centered in the diaphragm, second when sunlight alone is transmitted.

A more important professional use of the transit was the photographic measurement of the coordinates of Mercury relative to the sun. The U. S. Naval Observatory has long sponsored such work. On November 10th, German astronomers A. Wittmann and H. Wöhl took numerous large-scale photographs for this purpose at the Locarno, Switzerland, solar station of Göttingen University Observatory. Their work shows that the total duration of the

Above: The night before the transit, George Wood contrived this projection device from a 3-inch f/4.5 refractor lens, eyepiece, and translucent viewing screen (see picture at right).

Here, on the grounds of the Drumlin Farm Nature Center in Lincoln, Massachusetts, George Wood and other members of the Amateur Telescope Makers of Boston are watching the sun's limb intently. Roger Sinnott made this photograph between the times of third and fourth contacts.

transit was 12 seconds less than predicted.

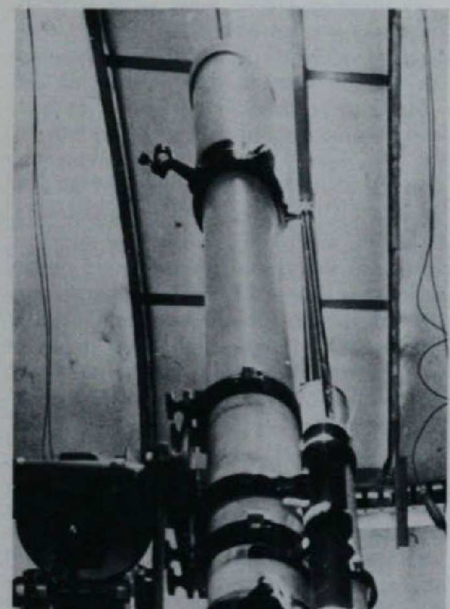
The nearly 150 reports already received by Sky and Telescope contain a wide variety of personal experiences, as well as useful records of the phenomenon itself. As described in the October issue, the beginning of the transit was visible from Europe and Africa, but not from North America. One of our correspondents who saw the opening stages was Charles A. Wood at Addis Ababa, Ethiopia, where he teaches at Haile Selassie I University. In the dome of its geophysical observatory, he used a 60-mm. guide telescope to cast a large solar image on a white screen, so more than 100 students could view the transit. At ingress, he was able to time the first visible notch made by Mercury at the sun's eastern limb, but thin clouds hampered viewing at egress.

Mr. Wood, who is an American from the Lunar and Planetary Laboratory in Arizona, supplies this historical footnote: Emperor Menelik II of Ethiopia observed the transit of November 14, 1907, and reported his results to the Astronomical Society of France, of which he was a member.

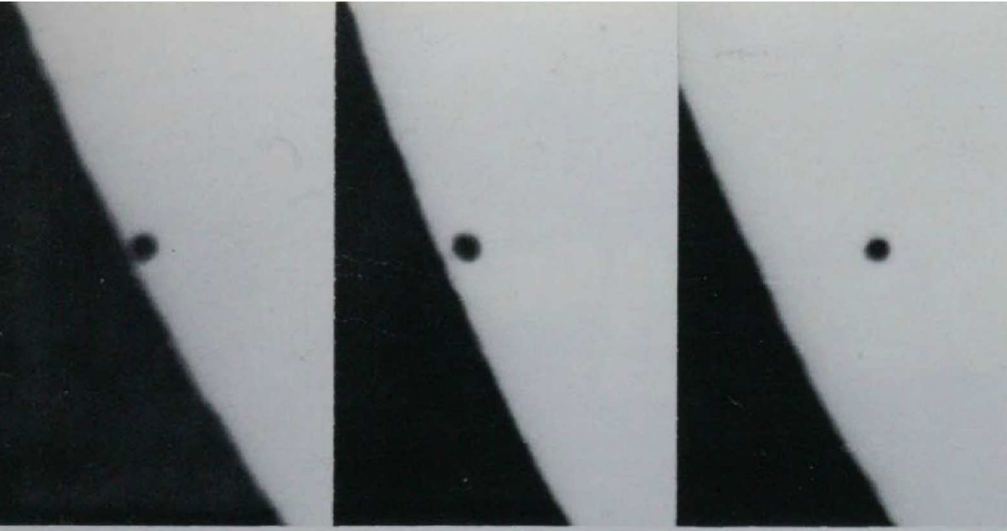
At Budapest, Hungary, Janos Papp and two other amateur astronomers conducted varied visual and photographic observations, during which they noted that even a 1.2-inch finder at 25x and 6x sufficed to show Mercury during transit. This result checks nicely with experiments made on the other side of the Atlantic by Roger Sinnott at Lincoln, Massachusetts. Using a No. 12 welder's glass as a sun filter, he ascertained that Mercury could be distinctly seen in 6 x 30 binoculars, but not at all with 2x opera glasses or the unassisted eye. During the transit, the angular diameter of Mercury was 9.9 seconds of arc, or 1/196 of the sun's diameter.

In one report received from England, Alan W. Heath of Nottingham tells of clouds and rain during the transit. Nevertheless, he was able to glimpse the planet nearly central on the sun and once again more than an hour later. According to Mr. Heath, Mercury as seen through thin clouds was not quite black.

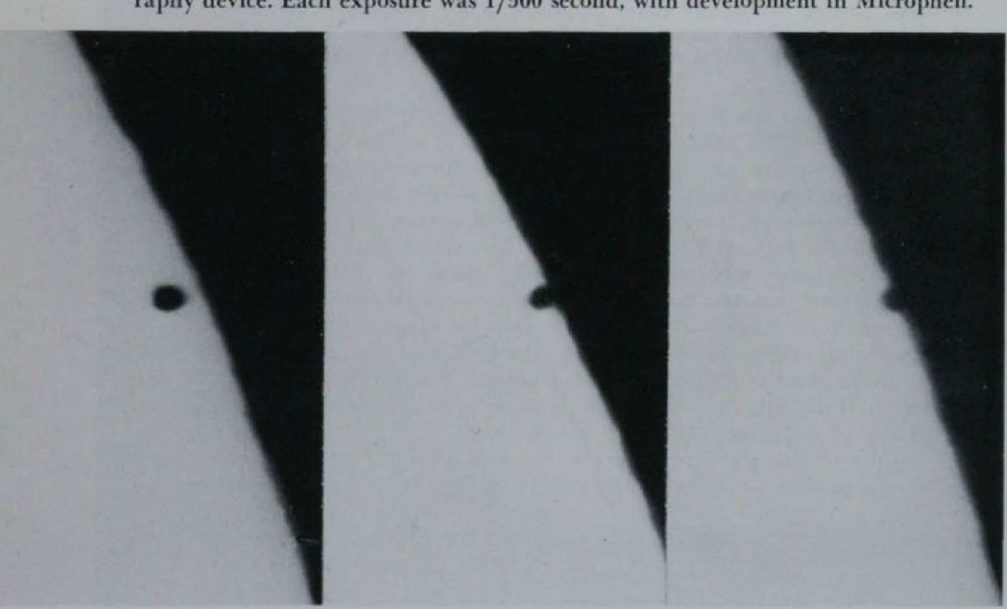
Much better weather prevailed in the




At Addis Ababa, Ethiopia, some 8,000 feet above sea level, students in the dome of the Geophysical Observatory watch Mercury cross a 16-inch projected solar image. Photo by C. Wood.



At Orcines, France, Prof. J. Dragesco of Paris University used a 4⅜-inch f/18 refractor for these close-ups of Mercury at ingress on the sun's disk (above) and at egress (below). In "superb weather but bad seeing," he noted first contact as roughly 7:48 Universal time. The frame at left above was taken at 7:49, the middle one a minute later, and the right one at 7:55. The frames below were at 13:15, 13:16, and 13:17, the last only half a minute before the computed last contact for his location. After reflection from a plane mirror, the solar image was passed through neutral and green filters and projected with a Plössl eyepiece onto Agfapan FF film in a 35-mm. camera equipped with a Leitz photomicrography device. Each exposure was 1/500 second, with development in Microphen.



eastern United States and Canada, where the end of the transit occurred not long after sunrise. The sky was generally very clear, but it was windy and cold.

The experiences of Lexie Cameron and Tom Stiff of Barrie, Ontario, may be typical of those of many Canadian amateurs. Their selected observing site was on the shore of a lake about three miles east of town. Proceeding there the night before, they cleared away a foot of snow and set up their 6-inch reflector, shortwave radio and antenna, working by moonlight. In the morning, a cold front passed before sunrise, and the two observers were able to time the egress of Mercury from the sun's disk.

One of the numerous amateur societies that viewed the transit was the Hilltop Astronomy League of New York City. Nine of its members assembled at 4:00 a.m. at the Riverdale Country School in the Bronx, on the spot where some of them had observed the May 9, 1970, transit of Mercury. The early meeting was arranged to look for Comet Kohoutek, which was detected in 10 x 50 binoculars as a 7th-magnitude object. Saturn and the moon were inspected in club president Barrett L. Brick's 3½-inch Questar until dawn. As the sun appeared above the low apparent horizon, Mercury could be seen already in transit, and was followed for about 1½ hours with three telescopes.

Steven Kawaler of Valley Stream, New York, gives an interesting aside on the public response to the transit. To get a nearly unobstructed horizon, he set up his 4¼-inch reflector at a busy intersection, where about 150 cars passed before the event ended. Contrary to his expectation, only four motorists stopped.

"One told me that the eclipse was June 30th; another sought traffic directions; a policeman wanted to know what was going on; and as I was packing up, a man asked if that was a telescope I had!" Mr. Kawaler recounted. However, this relative freedom from interruptions helped him make satisfactory timings of the last two contacts.

In the United States, the great majority of observers were concentrated close to the Atlantic coast from Maine to Florida. Farther west, the low altitude of the sun as the transit ended caused increasing difficulties. Michael W. Koelling at Warrenton, Missouri, and Roland B. Hatton of Bartlesville, Oklahoma, are the two most westerly observers in the United States known to have seen the event. At Waterloo, Iowa, Tom Wagner managed to photograph Mercury on the sun when the planet's altitude was only about three degrees (see page 9).

A problem facing some more westerly observers was solved dramatically by Clay Sherrod of North Little Rock, Arkansas. As the sun rose on the morning of the transit, he realized that it would be hidden behind a large treetop as seen from his observatory, where five instruments were readied. He quickly climbed 40 feet to cut off the treetop and interfering branches, and then returned to share in successful visual and photographic observations. At nearby Little Rock, many members of the Mid-South Astronomical Research Society held a public viewing session on the University of Arkansas campus, which drew an early morning crowd of about 65.

Observers everywhere noted the lack of sunspots during the transit, unlike the situation in May, 1970, when Mercury's track across the solar disk carried it directly over a sizable spot (SKY AND TELESCOPE, July, 1970, page 23).

In New York City, Hilltop Astronomy League members (left to right) Dan Davis, Ed DeLuca, and Barrett L. Brick observed the transit with a Questar. Dr. M. Brick took this picture.

Contact Times

The most desirable visual observations that an amateur can make at a transit of Mercury are careful timings of the four contacts. In the past, astronomers have used such data in studying fluctuations in the earth's rate of rotation and in improving the orbital elements of Mercury.

Many correspondents have reported contact timings made in accordance with the recommendations in last October's issue, page 227. Thanks to this enthusiastic response, the analysis of 248 timings can be summarized here.

Telescopes used ranged from 2-inch refractors to a 22-inch Gregory-Maksutov telescope. The results confirm expectations that even a 2-inch aperture in careful hands can give useful timings. A comparison with the equipment available at previous transits indicates the growing popularity of catadioptric telescopes and of full-aperture solar filters for this work.

The first table lists all the observers' locations, in order of longitude. Limitations of space do not permit giving the names of timers and assistants, even though they played a vital part in the success of the program, nor has it been feasible to give club affiliations.

The second table lists the individual observed times for each contact. In the first column, the observer is identified by

LIST OF OBSERVERS OF MERCURY TRANSIT CONTACT TIMES

No.	*Place*	*Long.* ° ′	*Lat.* ° ′	*Observer*	**Telescope*
1	Addis Ababa, Ethiopia	−38 46	9 02	C. Wood	2.4L, 16P
2	Budapest, Hungary	−17 48	42 22	J. Papp	6M
3	Pisa, Italy	−10 24	43 43	Alessandretti	4L, 22P
4	Pisa, Italy	−10 24	43 43	Bertin	4L, 22P
5	Pisa, Italy	−10 24	43 43	E. Fabri	4L, 22P
6	Pisa, Italy	−10 24	43 43	Farinella	4L, 22P
7	Pisa, Italy	−10 24	43 43	Fiorio	4L, 22P
8	Pisa, Italy	−10 24	43 43	Florio	4L, 22P
9	Pisa, Italy	−10 24	43 43	Madella	4L, 22P
10	Pisa, Italy	−10 24	43 43	Martini	4L, 22P
11	Pisa, Italy	−10 24	43 43	Melle	4L, 22P
12	Pisa, Italy	−10 24	43 43	Meucci	4L, 22P
13	Pisa, Italy	−10 24	43 43	Patratti	4L, 22P
14	Pisa, Italy	−10 24	43 43	Riccardi	4L, 22P
15	Vico Morcote, Switz.	−8 56	45 56	Sir P. Smithers	10C, 270x
16	Orcines, France	−3 04	45 45	J. Dragesco	
17	Bedford, Nova Scotia	63 41	44 44	M. Edwards	2.4L, 75x
18	Livermore Falls, Me.	70 13	44 27	D. Burkard	2.4L, 100x
19	Westport, Mass.	71 04	41 33	G. Stone	6M, 9P
20	Somerville, Mass.	71 05	42 23	S. LaRiccia	6M, 100x
21	Fall River, Mass.	71 09	41 42	R. Slobins	8L, 12P
22	Fall River, Mass.	71 10	41 44	K. Delano	8C, 127x
23	Needham, Mass.	71 13	42 18	J. Sterling	3L, 6P
24	Needham, Mass.	71 13	42 18	J. Ashbrook	3L, 6P
25	Warren, R. I.	71 18	41 48	H. Sippen, Jr.	4¼M
26	Lincoln, Mass.	71 20	42 24	G. East	5C, 100x
27	Amherst, Mass.	72 31	42 24	3 observers	8M, 13P
28	Amherst, Mass.	72 31	42 24	4 observers	20M, 48P
29	Newington, Conn.	72 45	41 43	R. Morris	3¼L, 3P
30	W. Hartford, Conn.	72 49	41 57	C. Hammond	3L, 45x
31	Cheshire, Conn.	72 54	41 30	R. Toman	2.4L, 152x
32	Hamden, Conn.	72 54	41 20	A. Melillo	6M, 96x
33	Bethany, Conn.	72 59	41 26	3 observers	10L, 8P
34	Wilton, Conn.	73 11	41 12	G. Lenz	2L, 120x
35	Smithtown, N. Y.	73 14	40 52	R. Szilagy	3L, 55x
36	Stamford, Conn.	73 33	41 07	C. Scovil	22C, 164x
37	Stamford, Conn.	73 33	41 07	J. Gregory	22C, 164x
38	Stamford, Conn.	73 33	41 07	W. Glenn	6M, 12P
39	Stamford, Conn.	73 33	41 07	F. Glenn	6M, 12P
40	Garden City Park, N. Y.	73 39	40 44	J. MacDougall	6M, 96x
41	Greenwich, Conn.	73 40	41 06	D. Luders	—, 10P
42	Glen Oaks, N. Y.	73 42	40 45	C. Kluepfel	3½C, 160x
43	Valley Stream, N. Y.	73 42	40 41	S. Kawaler	4¼M, 5P
44	Oakland Gardens, N. Y.	73 45	40 45	H. Luft	8C, 80x
45	Saratoga Springs, N. Y.	73 53	42 59	P. Baum	3½C, 60x
46	Brooklyn, N. Y.	73 53	40 38	J. Finkelstein	2.4L, 106x
47	Bronx, N. Y.	73 54	40 54	M. Brick	3½C, 150x
48	Brooklyn, N. Y.	73 54	40 42	D. Widman	2.4L, 4P
49	Brooklyn, N. Y.	73 56	40 35	B. Einsohn	3½C, 80x
50	Tenafly, N. J.	73 58	40 56	A. Sacharoff	6M, 5P
51	Staten Island, N. Y.	74 08	40 32	Prof. Monaghan	6M, 70x
52	Staten Island, N. Y.	74 08	40 32	I. Robbins	3L, 150x
53	Staten Island, N. Y.	74 10	40 32	B. Auchter	
54	Colts Neck, N. J.	74 11	40 17	R. Tonneman	4¼M, 3P
55	Beach Haven, N. J.	74 13	39 36	M. Clements	8C, 80x
56	Marlboro, N. J.	74 14	40 20	K. Stone	6M, 200x
57	Mountainside, N. J.	74 21	40 40	R. Tuthill	
58	Mystic Islands, N. J.	74 22	39 33	R. Busdiecker	2.4L, —P
59	Pomona, N. J.	74 32	39 29	H. Taylor	6M, 5P
60	Princeton Junct., N. J.	74 37	40 18	J. Church	6L, 15P
61	Succasunna, N. J.	74 40	40 51	R. Kelley	6M, 10P
62	Abington, Pa.	75 09	40 08	C. Nathan	8M
63	Buckingham, Pa.	75 10	40 20	A. Ference	6M, 8P
64	Ambler, Pa.	75 10	40 09	G. Foley	3½C, 160x
65	W. Philadelphia, Pa.	75 11	39 58	A. Hull	8L, 43P
66	Wallingford, Pa.	75 22	39 52	D. Carman	3L, 125x
67	South River, N. J.	75 36	40 27	D. Buckley	2.4L, 175x
68	Parkers Ford, Pa.	75 36	40 12	D. Reiber	6L, 30P
69	West Chester, Pa.	75 36	40 01	E. Lurcott	10M, 5P
70	Chadds Ford, Pa.	75 36	39 53	A. Webber	10M
71	Ardsley, N. Y.	75 50	41 00	T. Bell	3½C
72	Elkton, Md.	75 50	39 36	R. Worden	4½M, 270x
73	Lancaster, Pa.	76 20	40 02	R. Pearlman	•3L, 131x
74	Lebanon, Pa.	76 24	40 18	K. Klett, Jr.	6M, 108x
75	Baltimore, Md.	76 31	39 18	T. Doughney	6M, 4P
76	Kensington, Md.	77 04	39 02	J. Korintus	10M, 162x
77	Washington, D. C.	77 04	38 53	V. Slabinski	6M, 3P
78	Washington, D. C.	77 04	38 53	W. Young	6M; 120x
79	Potomac, Md.	77 09	39 03	C. Baker	2L, 4P
80	Carlisle, Pa.	77 12	40 10	E. Dadurka	5L, 185x
81	Gaithersburg, Md.	77 12	39 08	J. Yates, Jr.	8C, 180x
82	Springfield, Va.	77 14	38 48	W. Dillon	4¼M, 10P
83	Triangle, Va.	77 20	38 34	R. Coke	2.4L, 127x
84	Greenville, N. C.	77 23	35 38	R. Taylor, Jr.	
85	Chambersburg, Pa.	77 37	39 55	G. Weeks	3½C, 80x
86	Hagerstown, Md.	77 46	39 37	R. Giovanoni	6L, 180x
87	Peterborough, Ont.	78 20	44 17	W. Morrison	2L, 6P
88	Markham, Ont.	79 20	43 56	J. Verdirame	2.4L, 117x
89	Pinehurst, N. C.	79 28	35 09	A. Clarke	8C, 80x
90	Toronto, Ont.	79 33	43 35	E. Austin	8M, 90x
91	Barrie, Ont.	79 34	44 25	L. Cameron	6M, 8L
92	Streetsville, Ont.	79 44	43 36	R. Hosking	12½M, 30P
93	Purgatory Mtn., N. C.	79 46	36 00	R. Hill	12½M
94	Greensboro, N. C.	79 54	36 04	D. Talbert	2L, 2P
95	Greensboro, N. C.	79 57	36 05	D. Harrington	14¼M
96	Boca Raton, Fla.	80 06	26 16	R. Nottingham	3½C, 80x
97	Salisbury, N. C.	80 29	35 41	J. Jones	16M, 180x
98	Kannapolis, N. C.	80 38	35 29	L. Frye, Jr.	4L, 126x
99	Columbia, S. C.	81 02	34 00	R. Ariail	5L, 94x
100	Switzerland, Fla.	81 38	30 03	G. Murphy	6M, 50x
101	Switzerland, Fla.	81 38	30 03	K. Simmons	6M, 96x
102	Boone, N. C.	81 40	36 20	D. Green	4L, —P
103	Clinton, S. C.	81 52	34 28	K. Carter	8C, 127x
104	Columbus, Ohio	83 02	40 02	I. Jaworiwsky	6M, 67x
105	Springfield, Ohio	83 50	39 57	P. Boller	2.4L, —P
106	Lebanon, Ohio	84 08	39 26	J. Rosencrans	4¼M, 90x
107	Hampton, Ga.	84 18	33 25	T. Faber	3½C, 80x
108	Hampton, Ga.	84 18	33 25	M. Wehner	3½C, 80x
109	Cincinnati, Ohio	84 31	39 06	M. Uroshevich	2.4L, 4P
110	Frankfort, Ky.	84 53	38 11	C. Hobson	4M, 4P
111	Carrollton, Ga.	85 06	33 34	R. Ernest	8C, 70x
112	Carrollton, Ga.	85 06	33 34	J. Gunn	2½L, 40x
113	Carrollton, Ga.	85 06	33 34	C. Edison	8M, 112x
114	Birmingham, Ala.	86 50	33 34	2 observers	8M + 3½C
115	Terre Haute, Ind.	87 25	39 26	L. Bodie, Jr.	10M, 18P
116	Milwaukee, Wis.	87 56	42 58	M. Wilson	—, 9P
117	Champaign, Ill.	88 14	40 06	J. DeTray	12L, 20P
118	La Grange, Wis.	88 36	42 47	J. Huling, Jr.	6M, 70x
119	New Orleans, La.	90 06	29 59	M. Guidry, Jr.	6M, 9P
120	Gray Summit, Mo.	90 50	38 29	W. Clark	8M, 100x
121	Centreville, Miss.	91 05	31 06	J. Causey	6M, —P
122	N. Little Rock, Ark.	92 16	34 49	4 observers	
123	Warrenton, Mo.	92 30	38 55	M. Koelling	3M, 55x
124	Bartlesville, Okla.	95 58	36 44	R. Hatton	2.4L, —P
125	Mexico City, Mexico	99 11	19 22	G. Mallén	4¼M, 99x

**Telescope:* The first figure is aperture in inches; L, refractor; M, reflector; C, catadioptric. Magnification, x, is given, or P, the diameter in inches of the projected solar image.

the number assigned to him in the first table. The second column is the Universal time as reported by the observer. Next comes the predicted UT for each geographical location, computed from the formulas on page 360 of the *American Ephemeris and Nautical Almanac* for 1973. Finally, the column headed $O - C$ gives the difference between the observed and the computed times. It is negative if the observed time is earlier than the predicted.

The tables omit a few very discordant times. It is believed that all the listed observations depended on WWV or CHU time signals, or the equivalent.

The beginning of the transit, Contact I, is defined geometrically as the moment when the disks of Mercury and the sun are externally tangent. In actual practice, a visual observer can only record the time of the first detectable notch in the solar limb, and so he tends to be systematically late. In fact, the 10 available observations of Contact I give an average $O - C$ of +18 seconds.

Contact II, the moment of internal tan-

OBSERVED AND COMPUTED CONTACT TIMES FOR MERCURY'S TRANSIT – NOVEMBER 10, 1973

Key to observers' numbers is given in the table on page 7.

CONTACT I

No.	Observed h m s	Computed h m s	O – C s
1	7 48 33	7 47 56	+37
3	48 26	48 10	+16
4	48 26	48 10	+16
6	48 25	48 10	+15
9	48 32	48 10	+22
10	48 34	48 10	+24
11	48 25	48 10	+15
12	48 06	48 10	– 4
13	48 25	48 10	+15
14	48 30	48 10	+20

CONTACT II

No.	Observed h m s	Computed h m s	O – C s
3	7 49 36	7 49 51	–15
4	49 36	49 51	–15
5	49 36	49 51	–15
6	49 37	49 51	–16
7	49 33	49 51	–18
9	49 36	49 51	–15
10	49 36	49 51	–15
11	49 35	49 51	–16
12	49 19	49 51	–32
14	49 41	49 51	–10

CONTACT III

No.	Observed h m s	Computed h m s	O – C s
2	13 15 38	13 15 37	+ 1
4	15 17	15 41	–24
5	15 25	15 41	–16
6	15 35	15 41	– 6
7	15 25	15 41	–16
8	15 30	15 41	–11
9	15 15	15 41	–26
10	15 28	15 41	–13
11	15 25	15 41	–16
12	15 31	15 41	–10
14	15 25	15 41	–16
15	15 28	15 41	–13
17	16 35	16 14	+21
18	16 13	16 16	– 3
19	16 09	16 17	– 8
20	16 01	16 17	–16
21	16 29	16 17	+12
22	16 10	16 17	– 7
23	15 29	16 17	–48
24	16 35	16 17	+18
25	15 45	16 17	–32
26	16 02	16 17	–15
27	16 05	16 17	–12
28	16 03	16 17	–14
29	15 45	16 17	–32
30	16 12	16 17	– 5
31	16 02	16 17	–15
32	16 02	16 17	–15
33	15 39	16 17	–38
34	16 16	16 18	– 2
35	15 52	16 18	–26
36	16 05	16 18	–13
39	16 15	16 18	– 3
40	15 55	16 18	–23
41	15 26	16 18	–52
42	16 09	16 18	– 9
43	13 15 57	13 16 18	–21
44	16 06	16 18	–12
45	16 23	16 17	+ 6
46	16 14	16 18	– 4
47	16 00	16 18	–18
48	16 26	16 18	+ 8
49	15 55	16 18	–23
50	15 32	16 18	–46
51	16 05	16 18	–13
52	16 04	16 18	–14
53	16 09	16 18	– 9
54	16 53	16 18	+35
55	16 05	16 18	–13
56	16 06	16 18	–12
57	15 45	16 18	–33
58	15 55	16 18	–23
59	15 44	16 18	–34
60	16 11	16 18	– 7
61	15 45	16 18	–33
62	16 15	16 18	– 3
63	15 50	16 18	–28
64	16 08	16 18	–10
65	16 02	16 18	–16
66	16 24	16 18	+ 6
68	16 03	16 18	–15
69	16 21	16 18	+ 3
71	15 49	16 18	–29
72	15 47	16 18	–31
73	15 50	16 18	–28
74	16 05	16 18	–13
75	15 42	16 19	–37
76	16 37	16 19	+18
77	15 54	16 19	–25
78	16 12	16 19	– 7
79	15 55	16 19	–24
80	16 08	16 19	–11
81	16 00	16 19	–19
82	16 03	16 19	–16
83	15 35	16 18	–43
84	15 58	16 19	–21
85	15 59	16 19	–20
86	16 11	16 19	– 8
87	16 05	16 18	–13
88	15 49	16 18	–29
89	16 07	16 20	–13
91	15 56	16 18	–22
92	16 09	16 19	–10
93	16 05	16 20	–15
94	16 06	16 20	–14
95	16 18	16 20	– 2
96	16 10	16 21	–11
97	16 29	16 20	+ 9
98	16 07	16 20	–13
99	16 47	16 20	+27
100	16 11	16 21	–10
101	16 05	16 21	–16
102	15 59	16 20	–21
103	16 11	16 21	–10
104	15 46	16 20	–34
105	15 50	16 20	–30
106	16 22	16 20	+ 2
107	15 51	16 21	–30
108	15 51	16 21	–30
109	16 10	16 20	–10
110	15 54	16 21	–27
111	13 15 40	13 16 21	–41
112	15 37	16 21	–44
113	15 40	16 21	–41
114	16 10	16 22	–12
115	16 04	16 21	–17
116	15 42	16 20	–38
117	16 06	16 21	–15
118	16 11	16 20	– 9
119	16 34	16 23	+11
120	16 15	16 22	– 7
121	16 20	16 23	– 3
122	16 07	16 22	–15
123	16 01	16 22	–21
124	15 26	16 23	–57
125	15 56	16 24	–28

CONTACT IV

No.	Observed h m s	Computed h m s	O – C s
1	13 17 36	13 16 54	+42
2	17 19	17 17	+ 2
4	16 49	17 21	–32
5	17 00	17 21	–21
6	17 00	17 21	–21
7	17 00	17 21	–21
8	16 55	17 21	–16
9	16 49	17 21	–32
10	16 58	17 21	–23
11	17 01	17 20	–20
12	16 50	17 21	–31
14	16 45	17 21	–36
15	17 08	17 23	–14
16	17 30	17 25	+ 5
17	17 59	17 54	+ 5
18	17 37	17 56	–19
19	17 38	17 57	–19
20	17 41	17 57	–16
21	17 44	17 57	–13
22	17 33	17 57	–24
23	17 31	17 57	–26
24	17 55	17 57	– 2
25	17 31	17 57	–26
26	17 37	17 57	–20
27	17 41	17 58	–17
28	17 40	17 58	–18
29	17 25	17 58	–23
30	17 26	17 58	–32
31	17 38	17 58	–20
32	17 32	17 58	–26
33	17 35	17 58	–23
34	17 59	17 58	+ 1
35	17 26	17 58	–32
37	17 39	17 58	–19
38	17 42	17 58	–16
39	17 33	17 58	–25
40	17 25	17 58	–33
41	17 20	17 57	–37
42	17 40	17 58	–18
43	17 36	17 58	–22
44	17 30	17 58	–28
45	18 03	17 58	+ 5
46	17 42	17 58	–16
48	18 00	17 58	+ 2
49	17 34	17 58	–24
50	17 12	17 58	–46
51	13 17 39	13 17 58	–19
52	17 38	17 58	–20
53	17 39	17 58	–19
54	18 19	17 58	+31
55	17 32	17 58	–26
56	17 38	17 58	–20
57	17 45	17 58	–13
58	17 19	17 58	–39
59	17 22	17 58	–46
60	17 42	17 58	–16
61	17 43	17 58	–15
62	17 35	17 58	–23
64	17 37	17 59	–22
65	17 38	17 59	–21
66	17 41	17 59	–21
67	17 47	17 59	–12
68	17 28	17 59	–31
69	17 35	17 59	–24
70	17 28	17 59	–31
71	17 33	17 59	–26
72	17 33	17 59	–26
73	17 23	17 59	–36
74	17 34	17 59	–25
75	17 18	17 59	–41
76	17 42	17 59	–17
79	17 23	18 00	–37
80	17 45	17 59	–14
81	17 44	17 59	–15
82	17 32	17 59	–27
84	18 05	18 00	+ 5
86	17 34	17 59	–25
87	17 25	17 59	–34
89	17 35	18 00	–25
90	17 35	17 59	–24
91	17 26	17 59	–33
92	17 41	17 59	–18
93	18 06	18 00	+ 6
94	17 50	18 00	–10
95	17 58	18 00	– 2
96	17 40	18 01	–21
97	17 52	18 00	– 8
98	17 48	18 01	–13
100	17 37	18 02	–25
101	17 39	18 02	–23
102	17 47	18 01	–14
103	17 37	18 01	–24
104	17 28	18 00	–32
105	17 34	18 01	–27
107	17 38	18 02	–24
108	17 38	18 02	–24
109	17 48	18 01	–13
110	17 22	18 01	–39
111	17 24	18 02	–38
112	17 26	18 02	–36
113	17 22	18 02	–40
114	17 40	18 02	–22
115	17 37	18 01	–24
116	18 01	18 01	0
117	17 32	18 01	–29
119	17 47	18 03	–26
120	17 45	18 02	–17
121	18 02	18 03	– 1
122	17 43	18 03	–20
123	17 33	18 02	–29
124	17 16	18 03	–47
125	17 34	18 05	–31

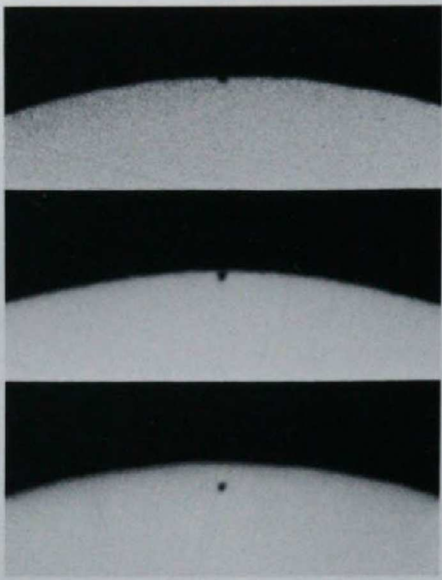
gency of the two disks, is a much more definite phenomenon. The mean of 10 timings gives $O - C = -17$ seconds. Students at the University of Pisa, Italy, under the direction of E. Fabri, contributed most of the observations of Contacts I and II, for as previously mentioned the beginning of the transit occurred when the sun was still below the horizon for the Americas.

As Mercury moved off the sun, Contact III was by definition the moment of internal tangency of the two disks. For this phenomenon, the great majority of observers timed the breaking of the thread of light between Mercury and the solar limb. One of the few who saw the so-called black drop was Trudy E. Bell, who used a 3½-inch Questar at Ardsley, New York. Here is her description:

"Mercury had a round black disk bigger than I expected, whose edge appeared serrated from the turbulence of our atmosphere. By 13:15:10 UT, Mercury was less than a diameter from the edge of the sun. At 13:15:49 I timed third contact: a little part of Mercury leaped out to the blackness beyond the solar limb, remaining as an elongated droplet that slowly became more flattened as the seconds passed."

The 116 listed times of Contact III show that on the average observers noted this event as occurring 16 seconds earlier than predicted. As the diagram shows, the scatter in the observations is considerable, but only about one residual in nine is positive.

Probably this 16-second difference is



Observers in the United States saw Mercury rise faster than the sun, as this sequence suggests. From bottom up, they were taken at 13:10, 13:15, and 13:16 UT. Nelson Brown, Jr., of Birmingham, Alabama, used a 3½-inch Questar for the lower two, while the last is with a 12½-inch reflector, by Mike Zebarth and his physics students at Gibson City High School in Illinois.

largely due to systematic errors of observation. Contact III is to the typical viewer a gradual affair, especially in poor seeing, with an interval lasting for several or many seconds when it is uncertain whether or not Mercury is just touching the sun's edge. The most probable time of contact is presumably the middle of this interval. But there is some tendency for an eager observer to press his stopwatch or call "Time" at the beginning of the interval of uncertainty. This may have happened in enough cases to explain part of the 16-second average discrepancy.

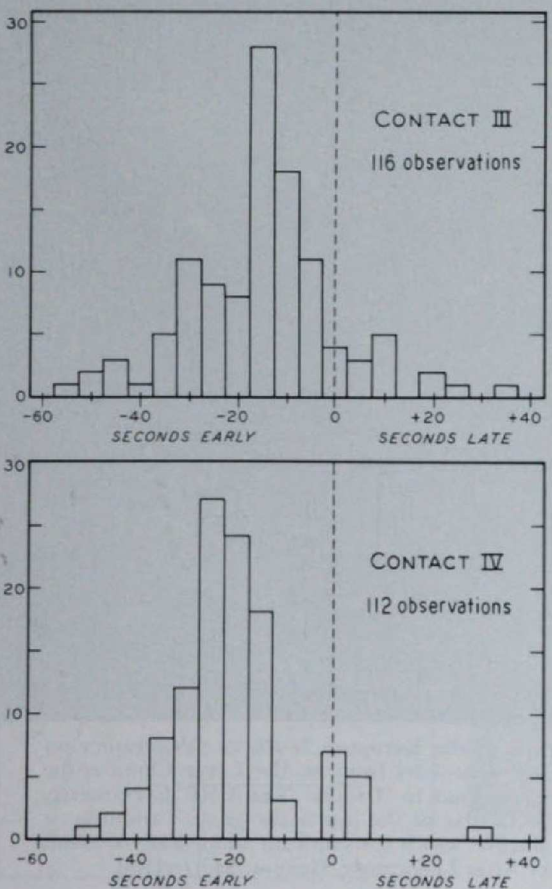
Similarly, Contact III was also observed earlier than predicted at the transits of 1953, 1960, and 1970, by 29, 11, and 8 seconds, respectively. These are means from 75, 81, and 118 timings published previously in SKY AND TELESCOPE.

Contact IV, the end of a transit, is by definition the moment of external tangency. However, the visual observer sees only a dwindling notch on the solar limb as Mercury moves off, and his recorded time of its last visibility will tend to be earlier than geometrical tangency.

A total of 112 timings are tabulated here, giving an average $O - C$ of -21 seconds. Many correspondents state that this contact was quite difficult to clock because of rippling of the solar limb. The low altitude of the sun at egress meant poor seeing for North American viewers in general.

A better idea of the respectable precision achieved in amateur observations of contacts is gained by recalling that during the November transit Mercury traveled its own diameter (10 seconds of arc) in 100 seconds of time.

In addition to those correspondents mentioned by name in this article, SKY AND TELESCOPE acknowledges the contribution of others who shared in observing programs, as well as of everyone who sent reports and photographs.



Left: Timings of Contacts III and IV on the facing page are summarized in these histograms, which show that observers tend to record these events earlier than would be expected from geometry alone.

Below: With the sun just three degrees above the horizon, Tom Wagner took this picture from near Waterloo, Iowa, with a Celestron 5-inch telescope and Bausch and Lomb solar filter. Mercury, the speck at top right, quit the sun only eight minutes later.