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Reports on Progress in Astronomy

SUNSPOTS IN 1970

Solar activity during 1970 remained at a level remarkably similar to that of the two previous years. The definitive Zürich sunspot number was 104·5 (ranging between 127·8 in February and 83·5 in December), a negligible fall from the 1968 and 1969 values of 105·9 and 105·5.

Forty-three sunspot groups with maximum corrected areas exceeding 500 millionths of the visible hemisphere were observed (one more than in 1969), of which twelve had maximum areas exceeding 1000 millionths.

The largest group of the year (exceeding 2500 millionths) crossed the disk between November 9 and 20 (C.M.P. November 14·6) in latitude 16° North.

Preliminary reports of solar flares $\geqslant$ Class 1 show a drop in number of only about 5 per cent. The number of S.I.D.s reported by Cable & Wireless Ltd was 39 (compared with 43 in 1969), although the number of S.E.A.s recorded on 25·5 KHz at Herstmonceux rose to 87 from 49. The majority of these, however, were of medium or low intensity.

The most active period of the year was from March to June and what appears to be a real decline in activity began at the end of the year.

It may still be premature to predict a sharp drop in activity after this unusually prolonged maximum phase, but present indications are that the sunspot number may well drop very markedly before the end of the next year.

P.S.LAURIE

COMETS IN 1970

The year 1970 was truly a fantastic one for cometary astronomy. Northern Hemisphere observers experienced what was undoubtedly the most spectacular comet since 1910, while the skies of the Southern Hemisphere were graced by the presence of two other bright naked-eye comets as well (although one of these was never observable from the Northern Hemisphere, and by the time the other could be seen there it had become a rather disappointing object). Four more comets came to the verge of naked-eye visibility and were easy objects in binoculars. With the aid of the orbiting observatories it was possible to record for the first time the spectrum of a comet far into the

ultra-violet. Extensive infra-red observations were also made. For sheer quantity, almost all records were easily broken: eleven periodic comets were recovered, two of them not seen since their discovery apparitions and missed at several intervening returns. The six new comets discovered—not in itself a record, although the four Japanese discoveries constitute a rather unexpected record—brought the number of comets reported to 17 (plus another one given a preliminary designation but not confirmed), and with the inclusion of several comets still observable from previous years the total number of comets under observation amounted to 27.

The 'annual' comet Schwassmann–Wachmann 1 was photographed by Elizabeth Roemer on May 4 with the 154-cm $f/13{\cdot}5$ Cassegrain reflector at the Catalina station of the Lunar and Planetary Laboratory. On the single 30-min exposure the comet appeared stellar and of magnitude 18·1. The comet's image has not yet been identified on a plate exposed by the same observer on March 13 with the Steward Observatory's 229-cm $f/9$ reflector on Kitt Peak. Observations were also made by Z.M.Pereyra with the 154-cm $f/5$ reflector at the Bosque Alegre station of the Córdoba Observatory, the comet on August 5 being of magnitude 17·5–18·0 and showing a possible fan-tail 1′ long.

1968 g, P/Comas Solá, faded slowly from total magnitude 13 and was under astrometric observation during the first few months of the year at some ten observatories. Short-exposure photographs by Roemer with the 229-cm reflector on January 5 showed a strongly condensed nucleus of magnitude about 15·8 and a tail 0′·3 long slightly north of west. Longer exposures the following month showed a structureless tail of 2′, while T. Urata (Shimizu, Japan) reported a 5′ tail. On March 14 only a trace of tail was photographed (Roemer), but the strong central condensation was still of magnitude 17·0. Cloud caused some interference during 10-min exposures with the 154-cm reflector on April 7, the cometary image appearing quite weak, though centrally condensed. On 229-cm reflector plates exposed on July 1 the comet was essentially stellar and of magnitude 19·3.

Observations 1968 October 27 to 1970 July 1

1968 j, Thomas, was photographed by Roemer on January 5 as a condensed object of magnitude about 17·5. It had faded to magnitude 18·0 when observed with the Catalina reflector on February 8 and March 7, and on the latter occasion a trace of coma was detected. Some fading took place during the next three months, but the comet was still sharply condensed and of magnitude 19·3 on July 5, at which

time it was 5·8 a.u. from the Sun and slightly farther from the Earth. Additional observations were possible at the opposition in 1971.

Observations 1968 December 19 to 1970 July 5, continuing

1969 a, P/Faye, was observed visually by J.E.Bortle using a 25-cm reflector at Stamford, Connecticut, on January 10, the total magnitude being estimated as 12·0. A similar estimate was made by M.Beyer, using a 26-cm refractor at Hamburg–Bergedorf, a few nights later. Plates exposed by Roemer with the Catalina reflector on February 7 showed nearly stellar images of magnitude 17·5. A month later the comet had faded to magnitude 17·8, and 30-min exposures in very good seeing revealed the barest trace of coma. Astrometric observations were also reported by H.L.Giclas (Lowell Observatory), A.Mrkos and R.Petrovičová (Kleť Observatory), B.Milet (Nice), T.Seki (Kochi), M.P.Candy (Perth), and V.L.Afanas'ev and S.I.Gerasimenko (Alma-Ata).

Observations 1969 May 17 to 1970 March 8

1969 b, Kohoutek, was recorded by R.L.Waterfield with his 15-cm *f*/4·5 Cooke triplet at Woolston, Somerset, on January 4. The estimated total magnitude was 12·5, and there was a very faint, diffuse tail 2′ long in p.a. 150° (towards the Sun!). Seki noted a brightening from magnitude 12 on January 8 to magnitude 10 a week later, and the latter figure was also estimated by Urata on February 2 and by G.Van Biesbroeck (using the 154-cm Catalina reflector) on the 9th. On February 26, Waterfield observed a much stronger tail than previously, with well-defined streamers 1′·0 to 1′·5 long in p.a. 0°, 320° and 300°. An objective-prism plate obtained by L.Kohoutek on March 11 with the 80-cm *f*/3 Schmidt at Hamburg-Bergedorf showed a continuum on which faint traces of emissions of C_3, CN and C_2 were suspected. At about the same time Beyer, observing visually nearby, judged the total magnitude as 9·9, and noted an 8′ tail in p.a. 348°. The comet was then at its closest to the Earth, some 1·8 a.u. away, and at about the same distance from the Sun, perihelion passage occurring ten days later. Bortle observed fading from magnitude 10·8 on April 4 to 11·0 on April 13 and 11·9 on May 8. On the first date there was a short, fairly broad tail about $2\frac{1}{2}$′ long in p.a. 20°. Three-minute exposures with the Catalina reflector (Roemer) on May 3 showed an essentially stellar nucleus of magnitude about 16·7 with a trace of tail extending less than 0′·1 to the east-north-east, although a 2′ tail could be detected visually. The last pre-conjunction observation seems to have been made by Mrkos on May 24.

The comet was reobserved in the morning sky by Roemer with the 154-cm reflector on October 1 as a sharply condensed magnitude

17·5 object at the apex of a fan-shaped coma. On October 31 this object appeared to be of magnitude 17·2, and there was a secondary nucleus or magnitude 19·0 located 15″ away in p.a. 350°. On November 29 the nuclei were of magnitudes 16·8 and 18·8, respectively, and their separation had increased to 20″; there was also a trace of tail extending 0′·2 north-west of the primary. A single exposure with the 229-cm reflector through clouds on December 26 showed the primary to be well condensed and not fainter than magnitude 19. There was only the barest trace of the secondary, located 27″ away in p.a. 0°.

Observations 1969 July 23 to end of 1970, continuing

1969 c, P/Whipple, was picked up after conjunction by Roemer with the 229-cm reflector on June 1, a 30-min exposure yielding a rather well-condensed image of magnitude 19·0. On plates taken with the 154-cm reflector on September 30 and October 31 the cometary images were very sharply condensed, the nearly stellar magnitude 17·5 nucleus being embedded in a small coma on the latter occasion. Ten-minute exposures with the 229-cm reflector on November 26 suggested that the comet had brightened to magnitude 17, but this was probably the result of poor seeing. Observations were also reported by Mrkos and Petrovičová and by Seki, this last observer estimating the total magnitude as 16 on October 22.

Observations 1969 July 20 to end of 1970, continuing

1969 f, P/Slaughter–Burnham, was photographed by Roemer with the Steward reflector on October 3 and November 26 and with the Catalina reflector on November 1. On the first occasion the seeing was excellent, and the comet appeared as a nearly stellar condensation of magnitude 19·8–20·0 with a very weak trace of tail westwards. The comet was slightly fainter on the other dates, but the tail, extending to 0′·2, was still present on November 26.

Observations 1969 November 4 to end of 1970, continuing

1969 g, Tago–Sato–Kosaka, which had been very striking for Southern Hemisphere observers during the last ten days of 1969, continued to be a fine object into January. On January 2, when the Earth was crossing the comet's orbital plane, A.F.Jones (Nelson, New Zealand) observed a faint sunward jet 6′ long in p.a. 235°; in 2·5 × 23 binoculars the coma magnitude was 3·6. F.D.Miller reports that this anti-tail was also present on direct photographs taken during the preceding week by V.M.Blanco and A.Gomez with the University of Michigan's Curtis Schmidt telescope at Cerro Tololo Interamerican Observatory. Observing near Brisbane, V.L.Matchett and M.V.Jones

consistently reported that the length of the main tail was 6 or 7° during January 5–11, although one or two observers indicated a length of 15°. A 20-min exposure on January 12 by W.J.H.Fisher with the 10-cm *f*/10 astrograph of the Carter Observatory, Wellington, showed the tail to be composed of faint filaments emerging from a point 10′ behind the head; the longest extended for almost 3° in p.a. 113°, and there were three others 0°·6 to 1°·5 long between p.a. 106° and 124°. The following night A.F.Jones noted a bright streamer visually near the northern boundary of the tail and estimated the coma magnitude as 4·0.

By then, though still at a declination of − 42°, the comet had moved far enough east of the Sun to become visible to observers at the latitudes of the southern United States. At this same time a team of astronomers from the University of Wisconsin succeeded in recording the comet's ultra-violet spectrum by means of instruments aboard the Orbiting Astronomical Observatory. The head was found to be bright in Lyman α to 30′ from the nucleus and measurable to some three times that distance. The OH band near λ 3070 was strong, and there was a continuum the intensity of which increased on either side of its minimum near λ 1900. By January 21 the comet had moved to declination − 15° and was widely observed even in northern Europe, although the presence of a Full Moon made it necessary to use optical aid. According to Beyer the magnitude was 4·2. K.Simmons (Jacksonville, Florida) could see the comet with the naked eye on January 27, however, while in 7 × 50 binoculars he estimated the magnitude as 5·1 and traced the tail to 1°·5 in p.a. 75°. K.Wenske, Hamburg, determined photoelectric magnitudes of 5·0 on January 30 and 5·4 two nights later. A photograph with his 19-cm *f*/2·6 Schmidt camera on the latter occasion showed a tail around p.a. 76° and a streamer at p.a. 90°. Waterfield remarked that the tail consisted of a rather diffuse, straight streamer centred in a broad, diffuse fan; in the best sky, on February 4, the straight streamer was 3° long, and a similar length was photographed by N.S.Chernykh at the Crimean Astrophysical Observatory. Spectroscopic observations at the Yerkes Observatory extended to a wavelength of λ 8500. New NH_2 bands were identified, this molecule being the dominant feature in the red and infra-red; the red and infra-red continuum was strong, and the Phillips C_2 bands and infra-red CN bands were also recorded. Observations even farther into the infra-red, at wavelengths λ 22 000 to λ 220 000, were made by F.J.Low and his collaborators at the University of Arizona.

A surge in total brightness, possibly by more than one magnitude, was reported by several observers around February 6. The increased intensity was also observed at infra-red wavelengths. Observations

by Roemer with the 154-cm reflector on the 7th showed tail rays covering the arc between p.a. 55° and 95° (and extending at least 15′ to the edge of the field), whilst a narrow jet, 1′ long in p.a. 80°, was noted photographically and visually. Considerable tail activity was also evident on a plate exposed some hours later by F.Seiler with his 15-cm *f*/2·3 Maksutov telescope near Munich, the activity apparently extending around to p.a. about 160°. Drawings made at about the same time by G.E.D.Alcock (Peterborough, Northamptonshire) show very similar features, together with a jet near p.a. 180°. Bortle reported a maximum coma diameter of 13′ on February 8, corresponding to 400 000 km. The nuclear magnitude was estimated by Roemer from 229-cm reflector plates to be 14·0 on February 3 and 15·5 (photovisual) on the 13th.

In spite of the nearly Full Moon, Simmons estimated the total magnitude as 6·8 on February 20, and an observation with 7 × 35 binoculars by P.Lancaster Brown (Beaconsfield, Buckinghamshire) on February 24 gave magnitude 7·5. B.Kroon, of Apeldoorn, The Netherlands, suggested that another outburst took place in early March, the magnitude being estimated in 7 × 50 binoculars as 8·4 on the 2nd and 7·8 a week later. Waterfield remarked that the tail had become very faint by March 2, and he was unable to photograph it on March 6. Three-minute exposures by Roemer with the Catalina reflector soon afterwards showed a weak, narrow tail extending only 0′·2 eastwards from a nearly stellar magnitude 16·2 nucleus embedded in a trace of coma. Somewhat longer exposures on yellow plates on March 14 (Steward reflector) showed a much fainter companion nucleus about 4″ east of the primary; the coma was rather asymmetrical, and there was only a suggestion of a tail. Simmons, using a 20-cm reflector, estimated a total magnitude of 9·4 on March 24, and he reported fading to magnitude 10·4 on April 7, although Bortle had noted a magnitude of 11·5 three nights before. On 30-min exposures with the Catalina reflector on April 6, Roemer found the comet to consist of a sharply condensed, but not stellar, nucleus of magnitude 17·2 in a trace of coma. Four weeks later it had faded to magnitude 18·1, and no further observations seem to have been possible.

Observations 1969 October 10 to 1970 May 4

1969 h, P/Churyumov–Gerasimenko, was recorded by Roemer on 10-min exposures with the Steward reflector on January 5 as a sharply condensed object of magnitude about 16·8. On February 3 there was a very sharp, stellar nucleus of magnitude 17·2 with faint traces of structure in p.a.'s near 100° and 200° to about 0′·2. Observations around this time by Gerasimenko and Afanas'ev at Alma-Ata mentioned a 10′ tail in p.a. 290°. With the Catalina reflector Roemer

recorded very small, sharply condensed, weak, magnitude 18·4 images of the comet on March 7, and she was unable to locate the comet on otherwise satisfactory 60-min exposures on May 3. Similar exposures with the 229-cm reflector five nights later, however, yielded quite small and sharp, but weak, images near magnitude 21·0. Astrometric observations were also made at the Nice and Kleť Observatories.

Observations 1969 September 9 to 1970 May 8

1969 i, Bennett, reported by the discoverer to be of magnitude 9·0 on the first two nights of the year, brightened steadily during the following weeks to become one of the greatest comets of the century and the most exhaustively studied comet of all time. Photographs by Pereyra with the Córdoba astrograph in mid-January showed a type I tail 25′ long, and by early February the length had increased to more than 2°. Visually, A.F.Jones estimated with his 32-cm reflector a total magnitude of 5·5 on February 9 and noted a 1° tail in p.a. 130°, while a fortnight later (in spite of moonlight) he detected some faint streamers on each side of the main tail. On the 28th, the coma magnitude was 3·6 to the unaided eye, the tail extending 2°·2 in p.a. 170–175°. On March 10, M.V.Jones remarked on the extremely bright nucleus and how little material seemed to surround it; in his 10-cm refractor the tail, 4° in length, appeared as a broad, featureless swath of light. This prominent type II tail was photographed by many observers throughout the Southern Hemisphere, and around the time of perihelion passage (March 20) it extended to perhaps 25° from the head. A substantially fainter, but almost as long, type I tail could also be photographed. Spectroscopic observations confirmed that this was a very dusty comet, the continuum being strong in both the head and the tail. Coudé spectrograms by F.Dossin at the European Southern Observatory also showed emissions of OH^+, CH^+, CO^+, and the lines of the violet CN (1,1) transition originally identified three months previously in the spectrum of comet 1969 g, as well as the other normal CN, C_2, CH, C_3, NH and Na emissions.

During March, comet 1969 i, the orbit of which was inclined at almost exactly 90° to the ecliptic, moved rapidly northwards, reaching its ascending node, greatest brilliancy (total magnitude 0 or even slightly brighter), and its least distance from the Earth (0·69 a.u.) soon after perihelion. Passing some 32° due west of the Sun, with an overlap of only a few days the comet ceased to be visible in the Southern Hemisphere and emblazoned the skies of the Northern. On March 28, Bortle, observing with the naked eye, judged the total magnitude as 0·5 (corrected for the rather considerable extinction), while the magnitude of the brilliant central condensation was 1·7. The difference between the two quantities remained more or less constant, the total

magnitude being down to 1·4 on April 4 and 2·4 on the 13th. On March 31, Alcock traced the type I tail out to 10° from the head, and the type II tail was at least 20° long. Bortle noted that the type I tail attained a maximum naked-eye length of 12° on April 6, while on the 11th Waterfield followed the type II tail for 25°. Wide-angle photographs taken by A.S.McClure at Mount Pinos, California, on April 5 showed a type II tail at least 20° long, while the type I tail appeared to extend to more than 25°. A remarkably condensed knot could be seen fully 8° from the comet's head. Considerable distortions in the tail were also reported by several other photographic observers. Observing visually, at times with a 55-cm Maksutov reflector, Bortle reported up to five or six spiral arcs of luminous material radiating from the central condensation and apparently sweeping from south to north. He also noted luminous hoods or envelopes, the comet's overall appearance being strongly reminiscent of G.P.Bond's drawings of comet 1858 VI. Behind the condensation he observed a parabolic-shaped region that seemed to contain relatively little luminous material, and within it was the so-called 'shadow of the nucleus'. The spiral arcs were also photographed by astronomers using long-focus reflectors. Hundreds of exposures by J.W.Fountain, S.M. Larson and others with the 154-cm Catalina reflector showed clearly that these spirals were a continuum feature.

Scans in Lyman α, obtained on April 1 and 2 from the satellite OGO–5 by J.-L.Bertaux and J.Blamont, University of Paris, revealed a hydrogen envelope with dimensions 9° by 6° in which there was a central, more intense region 2° by 0°·5. They estimated the mass of the hydrogen to be 2×10^{12} g. Many observations were also made in the infra-red. At the Asiago Astrophysical Observatory P.L.Bernacca and A.Mammano detected the infra-red CN (1, 0) band at λ 9148 (the strong continuum rendering it impossible to identify any other emission features with certainty); while at the University of Minnesota R.W.Maas, E.P.Ney and N.J.Woolf noted a sharp peak in intensity at λ 100 000, which they attributed to the presence of silicates. Air-borne observations by Low and his colleagues set an upper limit for the intensity at λ 700 000.

By May 2 the total magnitude was down to 4·4 (Bortle). Around this time the Earth was near the comet's orbital plane, but no observations of an anti-tail have been reported. However, as expected, the type II tail straightened out and became narrower; it also maintained its apparent length, Kroon reporting lengths of 22° in a very clear sky on April 30 (indicating an actual length of 1·2 a.u.) and 20° on May 5, while Alcock judged at least 19° on May 4. On May 29, Bortle estimated a total magnitude of 7·0, and around this time Alcock was still observing a tail-length of up to 9°. Photographs by

Waterfield showed several tail streamers fanning around p.a. 335°, and there was a definite elongation of the coma in p.a. 240–270°. Similar features were also noted on June 1 by Roemer, who estimated that the nucleus was of magnitude 15·0, but it was not completely resolved from the coma. On July 2 the strongly exposed magnitude 15·5 condensation was embedded in a coma 0′·5 across and located mainly to the north-west. Bortle last observed the tail visually on July 8, the length then being 0°·5, but five nights later he found that the diameter of the coma had increased to some 8′ (i.e. 900 000 km). Waterfield remarked that photographically the tail had become a short, faint, diffuse, wide fan when he last recorded it on July 26. Short exposures a few hours later by Roemer produced sharply condensed images of magnitude 15·8, again with a trace of coma mainly to the north-west. Visual estimates by Bortle indicated fading from magnitude 9·0 on August 5 to 10·6 on September 13, while photographic estimates by Waterfield ranged from magnitude 10·5 on July 14 to 12·8 on September 23—at which time the comet was near its maximum northern declination of + 83°. On September 26 the comet, including a trace of tail, could easily be seen with the 229-cm reflector (Roemer), and photographically there was a sharply condensed nucleus of magnitude about 17·4. Photographic observations were also reported in September and October by Mrkos and by Milet, while Beyer made visual magnitude estimates of 12·2 on October 21 and about 13 on November 20. The comet was seen by Roemer on November 25 as a small, diffuse patch with a sharp condensation, and on 10-min exposures the nearly stellar, magnitude 18·1 nucleus was surrounded by a coma of diameter less than 0′·1.

Observations 1969 December 28 to end of 1970, continuing

1970 a was discovered by Takashi Daido, a physics student at Tohoku University, Sendai, on January 27·8. Within the hour, although by then twilight was well advanced, the comet had also been spotted by Shigehesa Fujikawa, of Onohara, and its image was subsequently found on a film exposed at about this time by M.Honda, Kurashiki, with his 5-cm *f*/4·5 patrol camera. Both Daido and Fujikawa were using 16-cm reflectors, with magnifications of 33 × and 23 ×, respectively, and the latter observer had spent some 111 hours comet hunting since finding 1969 d. Rather belatedly, it was learned that the new comet had been seen the previous morning by Kiyotaka Kanai, a high-school student from Sakai, Gumma.

At discovery, comet Daido–Fujikawa was an eighth-magnitude diffuse object in Aquila, some 35° north-west of the Sun and rapidly approaching it. Accurate positions were obtained on January 28 by H.Kosai at the Tokyo Observatory, and also by Urata and Seki.

All three observers remarked on the tail, which according to Seki extended 20′ in p.a. 330°. Seki noted brightening from magnitude 8·2 then to 7·7 on the 31st, and K.Tomita (Tokyo Observatory) gave the magnitude as 6 on February 2. Astrometric observations were also made by K.Locher (Grüt-Wetzikon, Switzerland), Milet, T.Yumoto (Shizuoka), Giclas, and T.Kurosaki (Utsunomiya, Tochigi). At Harvard, Massachusetts, M.Mattei estimated a total magnitude of 5·5 on February 5 (7 × 50 binoculars). Alcock, using 25 × 105 binoculars, noted a featureless tail, increasing from 20′ on February 3 to 50′ on the 8th, while on the 7th Roemer traced the tail out at least 4° in 7 × 35 binoculars, in spite of the bright dawn sky. The last observations seem to have been made on February 9, Seki photographing the comet then at an elongation of only 18° from the Sun, the magnitude being about 4. Attempts to observe the comet when it passed less than 0·07 a.u. from the Sun on February 15 were unsuccessful, both at visible and infra-red wavelengths, and it also seems to have been impossible to recover the comet after perihelion.

Observations 1970 January 26 to February 9

1970 b was periodic comet Pons–Winnecke, recovered by Roemer, assisted by R.A.McCallister, on 40-min exposures with the Steward reflector on February 3·5 as a strong, essentially stellar object of magnitude 18·8. The comet was later identified on Catalina plates taken on January 11, the magnitude then being about 20·5. It was still essentially stellar in March, the magnitude again being estimated as 18·8, although on the 13th a trace of coma extended to the south-west. There was brightening to magnitude 18·2 on April 7 and 18·1 on May 8. On June 7 the comet was observed visually with the Catalina reflector as a very sharp condensation with a trace of coma, the photographic magnitude being 17·8. In spite of the lengthy star trails, a 30-min exposure through haze on July 6 showed the cometary image to be quite sharply condensed, of magnitude 17·0, with the barest trace of coma. Observations were also made in July and August at the Kleť and Perth Observatories. The comet was last recorded (at low altitude and declination − 42°) with the Catalina reflector on November 1 as a weak spot, of magnitude 17·7, more diffuse than the stars, though with a certain amount of condensation.

Observations 1970 January 11 to November 1

1970 c, periodic comet Kopff, was recovered by Roemer and R.C.Elliott as an essentially stellar magnitude 19·6 object on plates taken at Catalina on February 7·5 and confirmed with the Kitt Peak instrument six nights later. On March 8 (Catalina) the nearly stellar, magnitude 18·6 nucleus was accompanied by a trace of coma, and in

April and May the nucleus had brightened to magnitude 17·4. The comet was still practically stellar on June 7 and July 5 (Catalina) and sharply condensed, magnitude 16·8 images were recorded on July 27 (Kitt Peak). Accurate positions were also reported between May and November by the Kleť and Perth Observatories, and it may be possible to observe the comet again at its opposition in late 1971, the expected magnitude then being about 21.

Observations 1970 February 7 to November 23 (continuing?)

1970 d, periodic comet d'Arrest, was recovered by Roemer and J.Schreur with the 229-cm reflector on March 14·5. On the 30- and 24-min exposures the cometary images were weak and rather diffuse, the magnitude being about 19·5. Sixty-minute exposures with the 154-cm reflector on March 7 and 8 had failed to record the comet, although a weak, diffuse, magnitude 19·0 image appeared on a 50-min exposure with that instrument on April 7. On May 7, in spite of poor seeing, the comet was a surprisingly easy object visually for the 229-cm reflector. Photographically there was a moderately sharp condensation about 0′·1 in diameter embedded in a faint coma some five times the size; the magnitude was hard to estimate but probably about 17·9. A month later the comet's appearance on a Catalina plate was rather similar but a magnitude or so brighter. Seki photographed the comet on June 1, estimating the magnitude as 13, and a week later Urata observed it visually with a 20-cm reflector, judging the total magnitude to be 11. On July 4 Roemer observed the comet with the Catalina reflector's 15-cm finder, the total magnitude being 11-12. With the main telescope the comet appeared large and diffuse visually, with a stellar condensation near the visibility limit; while photographically there was a condensation of magnitude between 15·9 and 16·4 and about 5″ across, embedded in a coma of 10-12″. Image-tube spectrograms obtained by R.E.White with the Steward 229-cm reflector on July 9 and 10 showed the CN λ 3883 band to be the most prominent feature, although C_3, C_2 and tentatively CH and OH emissions were also identified, and there was a weak continuum. A pair of accurate positions was obtained on July 15 by Seki, who estimated the total magnitude then as 11. Astrometric observations were also made in July and August at Nice, Perth and Córdoba. On September 26, in very good seeing, Roemer observed the comet with the Steward telescope as a nearly stellar, magnitude 19·6 nucleus near the apex of an ill-defined, fan-shaped coma extending about 0′·3 north-eastwards. The comet's appearance was rather similar two months later—somewhat surprisingly, since the heliocentric distance had by then increased to 2·4 a.u., although P/d'Arrest has traditionally been much brighter after perihelion than before.

Observations 1970 March 14 to end of year, continuing

1970 e was periodic comet Ashbrook–Jackson, recovered by Pereyra with the 154-cm reflector at Bosque Alegre on May 1·4. The comet had a central condensation of magnitude 18·5 and a tail 15″ long, and the position confirmed suspected images recorded on March 9·3, the magnitude then having been 19·5. Observations were also made by Pereyra on May 2 and 3, and, on the 8th, well-condensed, magnitude 18·3 images of the comet were recorded by Roemer (Kitt Peak), probably with a trace of tail westwards, although there was some confusion with star images. On June 7 the comet was observed with the Catalina telescope as a sharply condensed nucleus of magnitude 17·5–17·7, with a trace of tail extending 0′·1 in p.a. 330°. On July 6 the tail extended 0′·2 in p.a. 345°. The comet was also observed at the Perth Observatory on six nights in July to September. During the entire opposition the comet remained south of declination − 35°, but it will be more conveniently placed for Northern Hemisphere observers during the 1971–72 opposition.

Observations 1970 March 9 to September 22, continuing

1970 f was a bright new comet first observed on May 18·3 from Barrack Point, New South Wales, by Graeme Lindsay White, a student at nearby Wollongong University College. Only 12° from the Sun, the comet was detected in 12 × 50 binoculars as a starlike object of magnitude 1–2 about 1½° west of Aldebaran, with a tail approximately 1° in length. White also suspected the comet the following evening, although he was then located at the Sydney Observatory, and there existed the possibility that he was seeing a ghost image produced by city lights. Back at Barrack Point, he observed the comet clearly on May 20, this time also with the naked eye, and the tail was then more than 10° long. The comet was independently discovered on May 21·6 by Emilio Ortiz, a second pilot for Air France who had also been one of the first observers of comet 1961 V (*Annuaire du Bureau des Longitudes pour* 1963, p. 343). On this occasion he was on the crew of Air Madagascar flight 281 (a Boeing 707 jet) from St Denis de la Réunion to Tananarive, and he watched the comet for some 40 min in the twilight sky. Its head, of first magnitude or slightly brighter, was located roughly midway between Aldebaran and Bellatrix, and the 10° tail was parallel to the line joining Bellatrix and Betelgeuse. The report by Ortiz, cabled upon his arrival in Tananarive, was received by the I.A.U. Central Telegram Bureau, Cambridge, Massachusetts, in somewhat garbled form a few hours after news of White's unconfirmed observations had arrived from Sydney. As a result, urgent requests for further information were sent to several points in the Southern Hemisphere, and unsuccessful attempts were made to observe the comet from various parts of the United States

that same evening. A third reported independent discovery was by Carlos Bolelli, night assistant at Cerro Tololo Interamerican Observatory, who saw the tail on May 21·9; the complete comet was photographed with the Curtis Schmidt telescope on the following two evenings. At least three independent sightings seem to have been made in the Brisbane area on May 19·3. One of these was made in Brookfield by Sylvia Jenkinson (now Lucas), who alerted her amateur-astronomer father to an object low in the sunset haze, but since no head could be detected they were unable to identify the object conclusively as a comet. Two early sightings were made in South Africa, by N.B.Dumas, Queenstown, on May 20·6 and by S.M.van Zyl, Pietersburg, the following evening; and F.Gomez, technician in charge of meteorological observations at the European Southern Observatory, saw the comet's tail about the time Bolelli had noticed it. Innumerable other independent discoveries were made throughout the Southern Hemisphere from May 22 onwards.

Although only one accurate position, by Pereyra on May 24, was initially available, and there were considerable inconsistencies among the approximate positions, it was soon evident that comet White–Ortiz–Bolelli belonged to the Kreutz group of sungrazing comets (the other most recent members of which are 1945 VII, 1963 V and 1965 VIII), and the problem of calculating its orbit was greatly simplified by assuming that the direction of perihelion was the same as for these other comets (longitude 282°, latitude + 35°). Perihelion passage had taken place on May 14·5 at a distance of 0·009 a.u. A useful series of approximate positions, extending from May 22 to June 7, was provided by Matchett, M.V.Jones and S.C.McMillan, Astronomical Amateurs' Club of Moreton Bay, Queensland, but accurate positions later became available from Cerro Tololo plates, a plate taken at the Perth Observatory on May 27, and some taken at Córdoba on June 5 and 6. Several observers were reporting a 15° tail between May 23 and 26. At the Smithsonian Astrophysical Observatory's station near Woomera on May 24 two tails were photographed—one straight and bright, the other much fainter and curving to the north. Matchett was still reporting a tail-length of 7° (in p.a. 105°) on June 1 and 5° on the 4th. The comet's head faded rapidly, according to the Woomera estimates from magnitude 4 on May 24 to 9 on June 3. On June 7 both M.V.Jones and A.F.Jones described the comet as faint, with no distinct head. By early June the comet had attained its maximum elongation of 22°. Attempts to recover it in the morning sky later in the year were unsuccessful, searches by Pereyra at Bosque Alegre in late August and by Roemer at Kitt Peak on October 4 having limiting magnitudes of about 19·0 and 19·5, respectively.

Observations 1970 May 18 to June 7

1970 g, the third new comet of the year, was discovered on July 3·7 by Osamu Abe, of Shinjo, Yamagata, using his home-made 10-cm reflector (magnification 20 ×). Abe, a 20-year-old farmer, had spent about 111 hr hunting for comets during the previous 14 months. Diffuse and uncondensed, and slightly fainter than Messier 74, the comet was a morning object in Aries, and it had moved about 0°·5 to the north-east when the discoverer observed it again 24 hr later. Accurate positions were measured by Kosai from plates exposed on July 5 and 6 by Seki, and other early positions were obtained by D.Harwood and D.Gans with the Perth astrograph, by Van Biesbroeck with the Catalina reflector, and by P.Wild with the 40-cm Schmidt at Zimmerwald, Switzerland. Magnitude estimates by A.F.Jones (32-cm reflector) gave 10·0 on July 8 and 9·9 on the 15th. A wide-field photograph by C.E.Scovil, taken on July 13 with the 55-cm Maksutov reflector at Stamford, Connecticut, showed a strong central condensation and a very faint, fan-shaped tail extending 15′ around p.a. 210° and containing several short streamers. Beyer estimated a magnitude of 8·2 on July 29 and a photoelectric determination by Wenske gave magnitude 7·3 six nights later. The comet continued to brighten steadily, several observers giving the magnitude as about 6·5 during the second half of August. During the first week of September, comet Abe passed its least distance from the Earth (0·8 a.u.) and was near its maximum declination of + 74°. Photoelectric measurements by Wenske, as well as visual estimates by Bortle—now observing from his new location at Stormville, New York—were accordant in establishing the comet's maximum brightness as magnitude 5·9 around September 20, and a number of observers reported seeing the comet faintly with the unaided eye.

On August 25, Bortle observed visually a tail 12′ long in p.a. 163°, and on September 2 he noticed two tails, their position angles differing by about 45°. The main tail attained a length of 2° on September 20, on which date the secondary tail was 45′ long and the angle between the tails some 30°. Waterfield and R.H.S.South gave a similar description a night or two later, a 30-min exposure showing the main branch 1°·5 long in p.a. 80° and the fainter branch 0°·5 long in p.a. 65°. Wenske remarked that the tail was invariably very weak on blue plates, as compared to red-sensitive plates, in spite of the fact that streamers could be detected visually. Nevertheless, at the University of Michigan, Miller reported that the filamentary tail was very active on September 2, and a fine spread of streamers appears on a 4-min exposure by S.van den Bergh on blue plates with the 122-cm Palomar Schmidt telescope on October 2. Very weak traces of tail rays, extending about 2′·5 from the nucleus in p.a. 50–80°, were recorded by Roemer on a 5-min exposure with the Steward 229-cm reflector on

October 5, while 30-sec exposures showed a rather sharp, but definitely non-stellar, condensation of magnitude about 14·5. Three-minute exposures with the Catalina reflector on October 31—some ten days after the comet passed perihelion—showed a sharply condensed, magnitude 13·4 nucleus in a trace of coma of diameter about 0′·2. Bortle gave the total magnitude as 7·5 on October 28 and was surprised to find the comet a full magnitude brighter on November 7. Beyer confirmed this rise in brightness, estimating the magnitude as 6·6 the next night. An estimate by W.Singer, Keene, New Hampshire, also gave magnitude 6·5 on November 17.

Around November 23 the comet passed some 21° due north of the Sun, and when next reported, by Seki on December 6, it had faded to magnitude 8·5. Visual observations by Simmons, and also by L.Boethin (Mudeng, near Bangued, The Philippines) on December 27 and 28 indicated a magnitude of 8·6, both these observers remarking on the very bright central condensation.

Observations 1970 July 3 to end of year, continuing

1970 h, periodic comet Johnson, was recovered by Roemer and Elliott at the Catalina station on July 5·4. The comet was quite sharply condensed, of magnitude about 18·8, with a trace of tail to 0′·1 or more in p.a. 70°. Images of the comet were subsequently found on pairs of plates taken on 1969 May 17 and 25, the magnitude then being about 20. The only other observations at this return were made on 1970 October 3, when 229-cm reflector plates showed a quite sharp, but unexpectedly faint and weakly exposed, condensation of magnitude about 20·1 with a narrow tail extending 0′·2 in p.a. 60°.

Observations 1969 May 17 to 1970 October 3

1970 i was periodic comet du Toit–Neujmin–Delporte, identified by Charles T. Kowal as a slightly condensed, diffuse object of magnitude 19 on Palomar Schmidt plates taken on July 6·2 and 7·2. Previously observed only during a 3-month interval in 1941, this was the first of two single-apparition comets that had passed unobserved several times before being recovered by Kowal in 1970 on the basis of predictions by the writer. The effect of differential perturbations during close approaches to Jupiter in 1954 and 1966 had produced a considerable *reduction* in the uncertainty in the current prediction, although the comet was in fact unexpectedly close to the ephemeris. Since 1941 the revolution period has increased from 5·5 to 6·3 years. Roemer photographed the comet at Kitt Peak on July 27, when it appeared as a small, weak object of magnitude about 19·3, and observations were also made in early August by Pereyra at Bosque Alegre. Pairs of 40-min exposures with the Kitt Peak instrument also recorded the

comet on September 26 and October 5, the images being weak, of magnitude about 18·5, and moderately well condensed in the good seeing prevailing on the latter night.

Observations 1970 July 6 to October 5

1970 j, periodic comet Arend–Rigaux, was recovered independently by Roemer and G.Reskin at Kitt Peak on July 27·4 and by Pereyra at Bosque Alegre on August 1·2 and 7·2. Noted for its stellar appearance, the comet was true to form at its present return, the magnitude being estimated as 20·8 by Roemer and 20·5 by Pereyra. On September 26 (Kitt Peak) and November 1 (Catalina), Roemer estimated magnitudes of 18·9 and 18·8, respectively.

Observations 1970 July 27 to November 1

1970 k, periodic comet Jackson–Neujmin, the second of the comets missing since their discovery apparitions, was found by Kowal on Palomar Schmidt plates taken on September 6·4 and 7·4. Differential perturbations had again caused the range of uncertainty to be somewhat reduced, but the error in the orbit—derived from observations covering a 2-month arc in 1936—was such that the comet was 6° from the central prediction (corresponding to a ΔT correction of about − 7 days), although this was still well within the anticipated uncertainty. At recovery P/Jackson–Neujmin was unexpectedly bright, of total magnitude 14, and there was a central condensation and short tail. It was also observed later in September by Seki and by Mrkos, the former estimating the magnitude of the condensation as 16 on plates taken with his 22-cm *f*/5 camera. With the long-focus instruments at the University of Arizona, however, Roemer found the magnitude of the condensation to be 18·7 and 18·5 on October 1 and 5, respectively; the condensation was sharp, but not stellar, and there was a trace of coma. On October 31, the magnitude was about 18·4, but the comet was a magnitude fainter and essentially stellar (although there was still a faint coma, possibly as much as 0′·4 in diameter) when recorded for the last time in late November.

Observations 1970 September 6 to November 25

1970 l was periodic comet Encke, recovered by Roemer and McCallister with the 229-cm reflector on September 26·4 as a completely stellar object of magnitude 18·4. Attempts by Roemer, and also by Pereyra and Tomita, to recover the comet in July and August had been unsuccessful. An accidental discovery of the comet was made by van den Bergh with the Palomar Schmidt on October 4, this observer noting an extremely faint coma surrounding the stellar nucleus, the total magnitude being about 17. An 80-min exposure by Waterfield

and South on October 21 showed a circular condensation 20″ in diameter, surrounded by a very faint, diffuse outer coma about 1′·5 in diameter, the total magnitude being 14·5. On November 1, Chernykh photographed a coma 3′ across, in which the starlike magnitude 15 nucleus was eccentrically placed. Bortle was unable to locate the comet visually with his 32-cm reflector on November 7, but ten nights later it was visible in 10 × 50 binoculars as a large, nebulous mass 8′ in diameter and of magnitude 9·1, and by November 25 it had brightened to magnitude 7·9. Five-minute exposures by Roemer with the Catalina reflector on November 28 revealed a strong fan-shaped coma extending at least 0′·3 westwards, and there was a very sharp, magnitude 16·5 nucleus at the apex. R.G.Roosen reported that an 8-min exposure three nights later with the 37-cm *f*/2 Schmidt telescope of the Goddard Space Flight Center, near Greenbelt, Maryland, showed this very broad, fan-shaped extension out to at least 1′·5 and possibly to 2′·5.

Observations from OGO–5 showed the presence of a small hydrogen cloud surrounding this comet too. By December 7, Bortle was estimating a total magnitude of 6·9. On December 15 and 21, Beyer noted visually some faint rays extending 4′ somewhat north of west, the total magnitude being 6·3 on the latter date. Also on December 21, Simmons estimated a magnitude of 5·9 in 7 × 50 binoculars, while Beyer made it 6·1 the next evening. A final observation, made late on December 23 by R.Lima, of Jacksonville, Florida, when the comet was only 17° north-east of the Sun and 17 days from perihelion, desscribed a coma 8′ across, but at the very low altitude (3–5°) no magnitude estimate was possible. Astrometric observations were also made from mid-November onwards by Milet, Mrkos, Seki and Locher, and by M. Antal at the Skalnaté Pleso Observatory.

Observations 1970 September 26 to December 23, continuing

1970 m was discovered within five minutes of each other on October 19·4 by Shigenori Suzuki, of Kira, Aichi, using a 14-cm reflector, magnification 29 ×, and Yasuo Sato, Nishinasuno, Tochigi (15-cm reflector, 25 ×). The Tokyo Observatory was not able to confirm the reports until the following evening, and independent discoveries were made then by Tsutomu Seki, Kochi (20 × 120 binoculars), Akihiko Tago, Tsuyama, Okayama (15-cm reflector, 29 ×), and Toru Kobayashi, Imadate, Fukui (15-cm reflector, 29 ×).* Sato and Tago, both of them discoverers also of 1968 a and 1969 g, had respectively spent 120 and 202 hours comet hunting since finding the latter; while Seki, well known as the discoverer of five previous comets, found the

*It was originally reported, erroneously, that Kobayashi discovered the comet on October 19·4.

new one 145 search hours after 1967 n. Immediately before making their discoveries both Seki and Kobayashi had been observing comet 1970 g, somewhat fainter than 1970 m and about 18° north of it.

During the nights following its discovery, comet Suzuki–Sato–Seki was estimated by most observers as having a magnitude close to 7, and those using the larger instruments detected a central condensation. A photograph by Waterfield on October 28 showed a faint, straight, narrow fan-tail 10′ long in p.a. 70°, and a suggestion of a tail had been noted visually by Bortle the night before, when the coma was quite condensed, of diameter 5′ and magnitude 7·5. On November 2, Roemer recorded the comet on 2-min exposures with the Catalina instrument as a poorly condensed coma about 0′·3 in diameter, the surface brightness at the centre corresponding to a star of magnitude 16·0–16·5. On November 3, H.B.Ridley (Godalming, Surrey) remarked on how diffuse the comet had become since the week before. According to Beyer, the comet faded from magnitude 8·4 on November 7, to 9·8 on the 15th and 10·1 on the 24th, while on the 25th the magnitude was down to 11·4. The comet was so diffuse on November 26 that Roemer had considerable difficulty seeing it with the 229-cm reflector, and on 10-min exposures it showed as a very poorly condensed spot, about 0′·5 in diameter and unmeasurable. Mrkos was able to obtain positional measurements up until November 28, and Seki followed the comet until the 30th, estimating the magnitude then as 14.

Observations 1970 October 19 to November 30

1970 n was the designation given to a cometary object reported by K.I.Churyumov during a visit to the Abastumani Observatory. The diffuse object, of magnitude 8·0–8·5, was first noted on November 21·7 around the Ophiuchus–Serpens border, but the position could not be measured because of clouds. The object was again identified the following night, and an approximate position was determined. Clouds interfered with observations on November 23 and 24, although on the latter evening it could be verified that there was no diffuse object at the position occupied on the 22nd. The discoverer originally reported a position for November 24, and with the help of the two available positions, unsuccessful searches were made at several observatories from the 26th onwards. The object reported on the 24th was subsequently identified as a group of faint stars, however, so the failure of these searches is not completely conclusive. Nevertheless, the wide-field photographs that happened to have been taken of the area by R.Germann, Wald, Switzerland, on November 24 show stars down to ninth magnitude, but no comet.

1970 o periodic comet Wolf–Harrington, was recovered on November 25·1 by Roemer and McCallister with the 229-cm Steward

reflector. This recovery was the fiftieth that Elizabeth Roemer has made since she started her cometary work as a student at the Lick Observatory nearly 20 years ago; and it was the seventh of the eight she recovered during 1970 (her previous annual record being seven, in 1960). On the 60-min exposures P/Wolf–Harrington was a well condensed, but not stellar, object of magnitude 21·2 or brighter. An attempt to recover this comet with similar exposures on September 27 was not successful.

Observations 1970 November 25, continuing

1970 p was a new comet discovered by James E.Gunn on a plate of the cluster of galaxies Abell 194 exposed with the 122-cm Palomar Schmidt on October 27·5. Of total magnitude 16, there was a central condensation and a small tail. From the trailed image the discoverer ascertained the small daily motion, and asked J.W.Young to photograph the comet with the 61-cm reflector at the Table Mountain Observatory, Wrightwood, California. Plates taken there on November 6 show faint, threshold images of magnitude 15 or fainter. More satisfactory images were recorded by J.N.Bahcall with the 122-cm Schmidt on November 22 and 23. The comet was not reported to the I.A.U. Central Telegram Bureau until December 8, but from the semi-accurate positions available the writer was able to establish that the orbit was an ellipse of eccentricity about 0·3, perihelion passage having taken place early in 1969. The comet should have been an easy object at its opposition in 1969 June, at declination $-30°$ and perhaps as bright as magnitude 12–13, but it does not seem to have been recorded on plates taken at the time. The orbit could be refined using observations made in 1971 January–March, and its present character evidently arose as the result of a close approach to Jupiter in 1965. Before then the perihelion distance was about 1 a.u. larger than the present 2·4 a.u., and there seems to be a possibility that P/Gunn can in future be followed throughout its 6·8-year revolution period.

Observations 1970 October 27 to November 23, continuing

1970 q, periodic comet Väisälä 1, was recovered by Roemer and McCallister with the 229-cm reflector on December 25·3. On the 60-min exposures, taken in very good seeing though through variable clouds, the cometary images were stellar and of magnitude about 21·0.

Observations 1970 December 25, continuing

1970 r was discovered by Nobuhisa Kojima, a middle-school science teacher, with his home-made 31-cm *f*/5 reflector at Ishiki, Aichi, on December 27·8. For some four years Kojima has been attempting to

recover missing short-period comets, and he discovered 1970 r—which turned out to be a new short-period comet!—on plates exposed for P/Neujmin 2, which has not been observed since 1927. At discovery P/Kojima was a diffuse object of magnitude 14, with condensation, situated about 2° from Spica. The discovery plates, as well as some obtained two nights later, were accurately measured by both Kosai and Seki. Seki, and also Tomita, observed the comet themselves on December 31, the former detecting a short tail.

Observations 1970 December 27 to end of year, continuing

The following magnitude parameters (in the *Ipv* system, and for the total magnitude) have been provided by M.Beyer, Hamburg–Bergedorf:

Comet	No. of Obs.	Arc	H_0	n
1970 g	33	1970 July 29—Nov. 7	5·50 ± 0·07	2·71 ± 0·21
1970 l	9	1970 Nov. 20—Dec. 22	10·83 ± 0·10	5·13 ± 0·31
1970 m	6	1970 Nov. 7–25	8·3*	4·8*

Photometric parameters have also been provided by J.E.Bortle, Stormville, New York:

Comet	No. of Obs.	Arc	H_0	n	Effective aperture (cm)
1969 a	5	69 Sept. 21—70 Jan. 10	8·81	4·98	25
1969 b	6	69 Sept. 21—70 May 8	8·20	2·33	25
1969 g	14	1970 Jan. 20—Apr. 4	6·52	2·30	6·8
1969 i	20†	1970 Jan. 2—Mar. 4	5·41	4·31	6·8
	31	1970 Mar. 28—Sept. 13	3·42	3·54	6·8
1970 g	27	1970 Aug. 3—Oct. 28	5·77	2·69	6·8
1970 l	10	1970 Nov. 17—Dec. 18	9·75	4·23	6·8
	9	1970 Nov. 17—Dec. 7	9·72	5·34	6·8
	2	1970 Dec. 7–18	9·15	2·40	6·8
1970 m	4	1970 Oct. 27—Nov. 16	7·89	3·17	6·8

An important paper by E.Everhart and N.Raghavan, published in *Astr. J.*, *75*, 258 (1970), lists for all the long-period comets observed from 1801 to 1969 quantities u_b = osculating $1/a$ minus original (barycentric) $1/a$ and u_a = future (barycentric) $1/a$ minus osculating $1/a$. The following results, in units of 10^{-6} reciprocal a.u., have been supplied by E.Everhart, University of Denver, for the comets of 1970. The first set has been calculated on the assumption that the osculation epoch is at perihelion, and the second set corresponds to the nearest standard

*Preliminary values. †Observations by A.F.Jones.

40-day date (following the recent recommendation by I.A.U. Commission 20 that such dates should, in general, be adopted by orbit investigators whenever perturbations are taken into account).

	Perihelion		40-day date			Total
Comet	u_b	u_a	u_b	u_a		$u_b + u_a$
1970 a	− 400	+ 445	− 400	+ 445	(1970 Feb. 23·0)	+ 45
1970 f	− 748	+ 114	− 748	+ 114	(1970 May 14·0)	− 633
1970 g	− 326	+ 259	− 326	+ 259	(1970 Oct. 21·0)	− 68
1970 m	− 820	+ 234	− 816	+ 230	(1970 Oct. 21·0)	− 587

Published ephemerides were also available for the following comets:

1969 d, Fujikawa. Two plates were taken by Roemer (Catalina) on February 8, but they do not reach the predicted magnitude (19·2).

P/Tempel-Swift. The revised ephemeris extended into February, but the comet was not expected to be brighter than magnitude 20.

P/Gale. As at the previous return, conditions were again unfavourable, and no observations seem to have been attempted.

P/Neujmin 2. An ephemeris was provided by the writer, and a rather pessimistic estimate of the brightness suggested that this comet would be of magnitude 17–18 by the end of the year. Since there are only two previous apparitions, in 1916 and 1927, the unknown non-gravitational effects could produce an error, perhaps up to $\Delta T = \pm 6$ days if they happen to be large. Good plates taken by Roemer with the Kitt Peak telescope on October 5 did not show the comet down to magnitude 20·0–20·5 (up to 1 magnitude fainter than predicted) and to $\Delta T = \pm 0{\cdot}8$ day. A further search on November 26 went down to magnitude 19·5 (1·5 magnitudes fainter than predicted) and concentrated on positive ΔT. Search plates were also taken with the Palomar Schmidt in early November (by G.A.Tammann) and early December (by Kowal); a more exhaustive search in 1971 January was also unsuccessful. From October onwards Seki and Kojima made searches out to $\Delta T = \pm 15$ days, but down to magnitude 15·0–15·5 only.

Tomita has reported some 1967 pre-recovery observations of P/Finlay (1967 IX). Plates taken on July 17 with the Dodaira 91-cm reflector show magnitude 16 images of this comet. The range of observation is thus 1967 July 17 to November 13.

The following continuation of the numerical designations of comets (in order of perihelion passage) is taken from *I.A.U. Circ.*, No. 2322 (1971). The perihelion times (T) are from orbits noted in these annual reports.

Comet		T		Name	Year and letter
1969	I	January	12·2	Thomas	1968 j
	II	April	19·0	P/Gunn	1970 p
	III	May	10·8	P/Harrington–Abell	1968 i
	IV	September	11·0	P/Churyumov–Gerasimenko*	1969 h
	V	September	23·0	P/Honda–Mrkos–Pajdušáková	1969 e
	VI	October	7·6	P/Faye	1969 a
	VII	October	12·4	Fujikawa	1969 d
	VIII	October	29·1	P/Comas Solá	1968 g
	IX	December	21·3	Tago–Sato–Kosaka	1969 g

On the following pages the elements of recently computed orbits are tabulated. The times are in Ephemeris Time, and the angles are referred to the ecliptic and mean equinox 1950·0. The column headed 'Obs.' gives the number of observations on which the calculation is based, the symbol *p* indicating predicted elements only; an asterisk means that non-gravitational acceleration terms were included. The column headed 'Arc' gives the interval of time covered by the observations used in the calculation. A date in parentheses indicates that the mean motion was assumed in order to link roughly with the observations at that time, rather than that actual observations were used in the orbit determination. If no reference is given, the elements are from as yet unpublished calculations by the writer (sometimes in collaboration with Z.Sekanina) perturbations by all nine planets having been taken into account.

*This is now the recommended transliteration from the Russian.

Ref.		Comet	T	q	e	*Elements of* P y
—	1772	P/Biela	72 Feb. 17·675	0·99038	0·72588	6·87
—	1806 I	P/Biela	06 Jan. 2·3990	0·907159	0·745871	6·74
—	1826 I	P/Biela	26 Mar. 18·9498	0·902430	0·746575	6·72
—	1832 III	P/Biela	32 Nov. 26·6152	0·879072	0·751299	6·65
—	1843 III	P/Faye	43 Oct. 17·6437	1·692255	0·555816	7·44
—	1846 II	P/Biela (primary)	46 Feb. 11·4942	0·856440	0·756599	6·60
—	1846 II	P/Biela (secondary)	46 Feb. 11·5782	0·856460	0·756608	6·60
—	1846 III	P/Brorsen	46 Feb. 25·8671	0·650112	0·793086	5·57
—	1851 I	P/Faye	51 Apr. 2·4433	1·699909	0·554866	7·46
—	1852 III	P/Biela (primary)	52 Sept. 23·5432	0·860594	0·755828	6·62
—	1852 III	P/Biela (secondary)	52 Sept. 24·2212	0·860625	0·755879	6·62
—	1857 II	P/Brorsen	57 Mar. 29·7458	0·620510	0·801727	5·54
—	1858 V	P/Faye	58 Sept. 13·3850	1·694100	0·555725	7·45
(1)	1866 I	P/Tempel–Tuttle	66 Jan. 11·6346	0·976477	0·905716	33·3
—	1866 II	P/Faye	66 Feb. 14·4757	1·682119	0·557598	7·41
(2)	1867 I	P/Stephan–Oterma	67 Jan. 20·6330	1·575435	0·858358	37·1
—	1868 I	P/Brorsen	68 Apr. 17·9217	0·597025	0·807977	5·48
—	1869 III	P/Tempel–Swift	69 Nov. 19·3053	1·063102	0·658121	5·48
—	1873 II	P/Tempel 2	73 June 25·8350	1·344165	0·552594	5·21
—	1873 III	P/Faye	73 July 18·9847	1·682547	0·557381	7·41
—	1873 VI	P/Brorsen	73 Oct. 10·9822	0·593793	0·808825	5·47
—	1878 III	P/Tempel 2	78 Sept. 7·7717	1·339700	0·553688	5·20
—	1879 I	P/Brorsen	79 Mar. 31·0345	0·589846	0·809820	5·46
—	1880 IV	P/Tempel–Swift	80 Nov. 8·4970	1·067202	0·657333	5·50
—	1881 I	P/Faye	81 Jan. 23·1579	1·738122	0·548965	7·56
—	1888 IV	P/Faye	88 Aug. 20·1804	1·747990	0·547457	7·59
—	1891 V	P/Tempel–Swift	91 Nov. 17·8659	1·086420	0·652988	5·54
—	1894 III	P/Tempel 2	94 Apr. 23·7444	1·350670	0·551106	5·22
—	1896 II	P/Faye	96 Mar. 19·5194	1·736934	0·548973	7·56
—	1899 IV	P/Tempel 2	99 July 29·0368	1·388620	0·542083	5·28
(3)	1900 III	P/Giacobini–Zinner	00 Nov. 28·4843	0·931398	0·731589	6·46
(4)			00 Nov. 28·4964	0·931521	0·731568	6·46
—	1904 III	P/Tempel 2	04 Nov. 10·9387	1·387862	0·542223	5·28
(5)	1905 II	P/Borrelly	05 Jan. 17·2945	1·395385	0·615117	6·90
(6)			05 Jan. 17·2951	1·395365	0·615230	6·91
—	1908 II	P/Tempel–Swift	08 Oct. 5·0749	1·152561	0·638120	5·68
—	1910 IV	P/d'Arrest	10 Sept. 16·8892	1·269851	0·636965	6·54
—	1910 V	P/Faye	10 Nov. 2·3531	1·655198	0·564949	7·42
(5)	1911 VIII	P/Borrelly	11 Dec. 18·4893	1·402660	0·614041	6·93
(6)			11 Dec. 18·4903	1·402655	0·614073	6·93
(3)	1913 V	P/Giacobini–Zinner	13 Nov. 2·5654	0·976005	0.720635	6·53
(4)			13 Nov. 2·5666	0·976009	0·720614	6·53
—	1915 I	P/Tempel 2	15 Apr. 14·5701	1·317561	0·559072	5·17
(5)	1918 IV	P/Borrelly	18 Nov. 17·0979	1·395732	0·615064	6·90
(6)			18 Nov. 17·0984	1·395787	0·615088	6·91

cometary orbits

ω °	Ω °	i °	Epoch	Obs.	Arc	Ref.
213·362	260·222	17·055	72 Feb. 21·0	—*	1772–. . .–1833	—
218·1036	243·3533	13·5913	05 Dec. 25·0	19*	1805, 1826, 1832–33	—
218·2894	253·2573	13·5640	26 Mar. 30·0	26*	1826, 1832–33, 1846	—
221·6864	249·9436	13·2181	32 Dec. 3·0	26*	1826, 1832–33, 1846	—
200·0304	211·0140	11·3648	43 Oct. 7·0	77*	1843–. . .–1881	—
223·0866	247·4156	12·5773	46 Jan. 24·0	26*	1826, 1832–33, 1846	—
223·0902	247·4117	12·5786	46 Jan. 24·0	19*	1846, 1852	—
13·7978	104·1248	30·9166	46 Mar. 5·0	110*	1846, 1857, 1868, 1873	—
200·1492	210·9368	11·3506	51 Mar 19·0	77*	1843–. . .–1881	—
223·2176	247·2805	12·5507	52 Sept. 29·0	26*	1832–33, 1846, 1852	—
223·2198	247·2778	12·5520	52 Sept. 29·0	19*	1846, 1852	—
14·0187	103·0530	29·7994	57 Mar. 27·0	110*	1846, 1857, 1868, 1873	—
200·1425	210·9735	11·3607	58 Aug. 29·0	77*	1843–. . .–1881	—
170·9385	232·5773	162·6968	66 Jan. 11·0	122	1865–66, 1965	(1)
200·2062	210·9074	11·3605	66 Feb. 8·0	77*	1843–. . .–1881	—
357·5111	79·6284	18·1982	66 Oct. 6·0	128	1867, 1942–43	(2)
14·8253	102·3295	29·3711	68 Apr. 18·0	110*	1846, 1857, 1868, 1873	—
106·1236	297·9818	5·4050	69 Dec. 9·0	39*	1869–. . .–1908	—
185·1889	121·9836	12·7517	73 June 11·0	104*	1873–. . .–1915	—
200·3644	210·7973	11·3557	73 July 21·0	77*	1843–. . .–1881	—
14·8612	102·3052	29·4072	73 Oct. 9·0	110*	1846, 1857, 1868, 1873	—
185·1666	121·9806	12·7633	78 Sept. 13·0	104*	1873–. . .–1915	—
14·9348	102·2793	29·3845	79 Apr. 1·0	127*	1868, 1873, 1879	—
106·1431	297·9039	5·4029	80 Nov. 21·0	39*	1869–. . .–1908	—
201·1880	210·5951	11·3209	81 Feb. 9·0	77*	1843–. . .–1881	—
201·2122	210·5730	11·3019	88 Aug. 31·0	151*	1888–. . .–1926	—
106·6905	297·3893	5·3936	91 Nov. 4·0	39*	1869–. . .–1908	—
185·1154	121·9175	12·7370	94 May 12·0	104*	1873–. . .–1915	—
201·2682	210·5238	11·3213	96 Mar. 22·0	151*	1888–. . .–1926	—
185·6322	121·6501	12·6442	99 Aug. 14·0	104*	1873–. . .–1915	—
171·0530	197·4360	29·8338	00 Sept. 18·0	—	1900–01, 1913	(3)
171·0509	197·4325	29·8366	00 Dec. 7·0	101*	1900–. . .–1947	(4)
185·7697	121·6148	12·6454	04 Nov. 16·0	104*	1873–. . .–1915	—
352·3510	77·3815	30·4853	05 May 15·0	—*	1904–. . .–1960	(5)
352·3524	77·3812	30·4847	05 Jan. 15·0	164*	1904–. . .–1968	(6)
113·4992	291·0609	5·4453	08 Sept. 16·0	39*	1869–. . .–1908	—
173·7922	146·9214	15·7870	10 Sept. 6·0	37*	1910, 1923–24, 1943	—
199·5310	206·7773	10·5739	10 Oct. 16·0	151*	1888–. . .–1926	—
352·3732	77·3758	30·4415	11 Oct. 31·0	—*	1904–. . .–1960	(5)
352·3750	77·3755	30·4417	11 Dec. 10·0	164*	1904–. . .–1968	(6)
171·4840	196·3686	30·7461	13 Aug. 21·0	—	1900–01, 1913	(3)
171·4864	196·3662	30·7472	13 Nov. 9·0	126*	1913–. . .–1960	(4)
186·7133	121·1503	12·7624	15 Apr. 13·0	103*	1915–. . .–1956	—
352·3915	77·3684	30·4900	19 Mar. 23·0	—*	1904–. . .–1960	(5)
352·3984	77·3706	30·4914	18 Nov. 23·0	164*	1904–. . .–1968	(6)

Ref.	Comet	T	q	e	Elements of P y
—	1920 II P/Tempel 2	20 June 10·9278	1·316420	0·559301	5·16
—	1925 IV P/Tempel 2	25 Aug. 7·0388	1·313283	0·560096	5·16
—	1925 V P/Faye	25 Aug. 7·6510	1·618016	0·570769	7·32
(5)	1925 VIII P/Borrelly	25 Oct. 7·5250	1·388188	0·616393	6·88
(6)		25 Oct. 7·5266	1·388179	0·616450	6·89
(3)	1926 VI P/Giacobini–Zinner	26 Dec. 11·7081	0·993750	0·717015	6·58
(4)		26 Dec. 11·7084	0·993735	0·717005	6·58
—	1930 VIII P/Tempel 2	30 Oct. 5·7875	1·318688	0·558898	5·17
(6)	1932 IV P/Borrelly	32 Aug. 27·2921	1·385541	0·616726	6·87
(5)		32 Aug. 27·2931	1·385555	0·616713	6·87
(7)	1932 VII Newman	32 Sept. 24·5596	1·647088	0·999981	—
—	1932 IX P/Faye	32 Dec. 6·2349	1·619998	0·570415	7·32
(4)	1933 III P/Giacobini–Zinner	33 July 15·1474	0·999527	0·715993	6·60
(4)	1940 I P/Giacobini–Zinner	40 Feb. 17·2110	0·995605	0·716704	6·59
—	1940 II P/Faye	40 Apr. 24·8936	1·653929	0·565188	7·42
(8)	1940 IV Whipple–P.	40 Oct. 8·0299	1·082327	0·981072	432
(9)	1941 I Cunningham	41 Jan. 16·2347	0·367763	1·000469	—
(2)	1942 IX P/Stephan–Oterma	42 Dec. 19·0710	1·595337	0·860895	38·8
—	1946 III P/Tempel 2	46 July 2·3420	1·393328	0·542240	5·31
(4)	1946 V P/Giacobini–Zinner	46 Sept. 18·4860	0·995706	0·716679	6·59
(10)	1947 IX P/Faye	47 Sept. 28·4072	1·66327	0·563734	7·44
—		47 Sept. 28·4107	1·663263	0·563723	7·44
—	1948 XII P/Honda–Mrkos–P	48 Nov. 17·7172	0·559267	0·814204	5·22
—	1949 VI P/Shajn–Schaldach	49 Nov. 26·8914	2·234109	0·405054	7·28
—	1951 VIII P/Tempel 2	51 Oct. 25·2002	1·391237	0·542619	5·30
(6)	1953 IV P/Borrelly	53 June 9·4983	1·450043	0·604074	7·01
(5)		53 June 9·5153	1·450029	0·603971	7·01
—	1954 III P/Honda–Mrkos–P.	54 Feb. 5·1055	0·555636	0·815096	5·21
—	1955 II P/Faye	55 Mar. 4·6577	1·651837	0·565384	7·41
—	1957 II P/Tempel 2	57 Feb. 5·1977	1·369265	0·547684	5·27
(3)	1959 VIII P/Giacobini–Zinner	59 Oct. 26·9189	0·935954	0·728945	6·42
(4)		59 Oct. 26·9193	0·935955	0·728947	6·42
(11)	1960 IV P/Väisälä 1	60 May 10·8375	1·741495	0·635809	10·5
(6)	1960 V P/Borrelly	60 June 13·2402	1·454118	0·603396	7·02
(5)		60 June 13·2578	1·454105	0·603418	7·02
—	1962 VI P/Tempel 2	62 May 12·6901	1·363960	0·548989	5·26
—	1962 VII P/Faye	62 May 14·6933	1·608080	0·575714	7·38
—	1963 I Ikeya	63 Mar. 21·4748	0·632139	0·993377	932
(12)	1963 IV P/Johnson	63 June 9·076	2·247261	0·377570	6·86
—	1964 VII P/Honda–Mrkos–P.	64 July 6·5608	0·555746	0·815017	5·21
(1)	1965 IV P/Tempel–Tuttle	65 Apr. 30·0962	0·985082	0·903986	32·9
(4)	1966 I P/Giacobini–Zinner	66 Mar. 28·2908	0·933507	0·729400	6·41
(6)	1967 VIII P/Borrelly	67 June 17·7173	1·446599	0·604463	6·99
—	1967 X P/Tempel 2	67 Aug. 14·2509	1·366510	0·548397	5·26
—	1968 I Ikeya–Seki	68 Feb. 25·7055	1·696581	0·999152	89400

cometary orbits

ω °	Ω °	i °	Epoch		Obs.	Arc	Ref.
186·6556	121·1417	12·7618	20 June	5·0	103*	1915–. . .–1956	—
186·5804	121·1387	12·7711	25 July	29·0	103*	1915–. . .–1956	—
199·9272	206·5719	10·5857	25 July	29·0	205*	1910–. . .–1948	—
352·4242	77·3786	30·5108	25 Aug.	3·0	—*	1904–. . .–1960	(5)
352·4226	77·3787	30·5105	25 Oct.	17·0	164*	1904–. . .–1968	(6)
171·7529	196·2427	30·7387	26 Dec.	11·0	—	1926–27, 1933	(3)
171·7549	196·2424	30·7386	26 Dec.	31·0	126*	1913–. . .–1960	(4)
186·5974	121·1213	12·7569	30 Sept.	21·0	113*	1930–. . .–1967	—
352·5509	77·3082	30·5295	32 Aug.	21·0	164*	1904–. . .–1968	(6)
352·5510	77·3084	30·5295	32 July	17·0	—*	1904–. . .–1960	(5)
69·8025	245·3902	78·3863	32 Sept.	30·0	82	32 June 21–33 Jan. 20	(7)
200·0676	206·4665	10·5809	32 Nov.	29·0	205*	1910–. . .–1948	—
171·7715	196·2430	30·6839	33 July	27·0	126*	1913–. . .–1960	(4)
171·7921	196·2498	30·7414	40 Feb.	21·0	126*	1913–. . .–1960	(4)
200·5088	206·3701	10·5523	40 May	11·0	205*	1910–. . .–1948	—
235·7280	134·4497	54·7183	40 Oct.	8·0	70	40 July 28–41 Jan. 1	(8)
199·5766	295·8868	49·8093	41 Jan.	6·0	261	40 Sept. 19–41 June 17	(9)
358·2689	78·5996	17·8962	42 Oct.	18·0	128	1867, 1942–43	(2)
190·8561	119·4143	12·4310	46 June	29·0	113*	1930–. . .–1967	—
171·8105	196·2932	30·7269	46 Sept.	17·0	126*	1913–. . .–1960	(4)
200·5266	206·3504	10·5337	47 Oct.	22·0	—	1925–. . .–1970	(10)
200·5293	206·3500	10·5339	47 Sept.	12·0	211*	1932–. . .–1970	—
184·1235	233·0953	13·1599	48 Nov.	25·0	49*	1948–49, 54, 64, 69	—
215·2924	167·3938	6·1528	49 Nov.	20·0	64	1949 Aug. 29–Dec. 20	—
190·9958	119·3790	12·4326	51 Nov.	10·0	113*	1930–. . .–1967	—
350·9557	76·1779	31·0898	53 June	12·0	164*	1904–. . .–1968	(6)
350·9490	76·1780	31·0896	53 Dec.	9·0	—*	1904–. . .–1960	(5)
184·1345	233·0871	13·1955	54 Jan.	18·0	49*	1948–49, 54, 64, 69	—
200·5792	206·3116	10·5542	55 Feb.	22·0	211*	1932–. . .–1970	—
191·0334	119·2812	12·4701	57 Feb.	11·0	113*	1930–. . .–1967	—
172·8436	196·0299	30·9044	59 Sept.	29·0	—	1959–60, 1965	(3)
172·8443	196·0299	30·9038	59 Nov.	8·0	126*	1913–. . .–1960	(4)
44·4420	135·4275	11·2911	60 May	26·0	—	(1949), 1959–60	(11)
350·9739	76·1942	31·0665	60 June	15·0	164*	1904–, . .–1968	(5)
350·9747	76·1942	31·0661	60 Aug.	29·0	—*	1904–. . .–1960	(5)
191·0528	119·2769	12·4818	62 May	16·0	113*	1930–. . .–1967	—
203·5507	199·1253	9·0951	62 May	16·0	211*	1932–. . .–1970	—
336·2851	52·5045	160·6452	63 Apr.	1·0	76	1963 Jan. 4–Oct. 12	—
206·0921	118·1209	13·8543	63 June	20·0	—	(1949, 1956), 1963–64	(12)
184·1308	233·1272	13·1963	64 July	24·0	49*	1948–49, 54, 64, 69	—
172·9859	234·5520	162·7279	65 Apr.	30·0	122	1865–66, 1965	(1)
172·9199	195·9651	30·9442	66 Mar.	16·0	45*	1959–60, 1965	(4)
351·0288	76·1419	31·1155	67 June	19·0	164*	1904–. . .–1968	(6)
190·9790	119·2719	12·4738	67 Aug.	18·0	113*	1930–. . .–1967	—
70·8724	254·6278	129·3165	68 Mar.	5·0	176	67 Dec. 29–69 Nov. 4	—

Ref.		Comet	*T*	*q*	*e*	*Elements of* *P* y
(13)	1969 II	P/Gunn	69 Apr. 19·00	2·4431	0·3196	6·80
—	1969 V	P/Honda–Mrkos–P.	69 Sept. 22·9781	0·558686	0·814285	5·22
—	1969 VI	P/Faye	69 Oct. 7·5844	1·616284	0·574670	7·41
(14)	1970 a	Daido-Fujikawa	70 Feb. 15·8053	0·065742	1·0	—
(15)	1969 i	Bennett	70 Mar. 20·0459	0·537618	0·996272	1730
(16) (12)	1970 h	P/Johnson	70 Mar. 29·5893	2·200364	0·385090	6·77
			70 Mar. 30·5348	2·199980	0·385524	6·77
(17)	1970 f	White–Ortiz–Bolelli	70 May 14·4859	0·008879	1·0	—
(18)	1970 d	P/d'Arrest	70 May 18·4347	1·166801	0·655559	6·23
(19)	1970 b	P/Pons–Winnecke	70 July 21·0274	1·247378	0·635999	6·34
(20)	1970 k	P/Jackson–Neujmin	70 Aug. 6·4272	1·428009	0·654256	8·39
(21)	1970 m	Suzuki–Sato–Seki	70 Oct. 1·7980	0·405589	1·000373	—
(22)	1970 c	P/Kopff	70 Oct. 2·4066	1·566991	0·546136	6·42
(23)	1970 r	P/Kojima	70 Oct. 7·2505	1·631915	0·516791	6·21
(24)	1970 i	P/du Toit–Neujmin–D.	70 Oct. 8·1642	1·677050	0·508677	6·31
(25)	1970 g	Abe	70 Oct. 20·7005	1·112511	1·0	—
(26) (27)	1970 l	P/Encke	71 Jan. 9·9209	0·338897	0·847152	3·30
			71 Jan. 9·9820	0·338891	0·847162	3·30
(28)	1970 e	P/Ashbrook–Jackson	71 Mar. 13·6432	2·284615	0·399720	7·42
(29)	1970 j	P/Arend–Rigaux	71 Apr. 6·0213	1·444373	0·599095	6·84
(30)	1970 o	P/Wolf–Harrington	71 Sept. 1·1836	1·621786	0·536774	6·55
(31) (11)	1970 q	P/Väisälä 1	71 Sept. 12·3002	1·866130	0·628958	11·3
			71 Sept. 14·641	1·866528	0·629005	11·3

cometary orbits

ω °	Ω °	i °	Epoch		Obs.	Arc	Ref.
197·20	68·05	10·39	—		6	70 Oct. 27–71 Mar. 3	(13)
184·1647	233·1056	13·1686	69 Sept.	16·0	49*	1948–49, 54, 64, 69	—
203·6666	199·0496	9·0823	69 Oct.	26·0	211*	1932–. . .–1970	—
266·6497	29·9065	100·1706	—		42	1970 Jan. 27–Feb. 9	(14)
354·1553	223·9612	90·0450	70 Apr.	4·0	153	69 Dec. 30–70 Apr. 10	(15)
205·9930	117·8651	13·8993	70 Apr.	4·0	*p*	(1956), 1963–64	(16)
206·0495	117·8236	13·8877	70 Apr.	4·0	*p*	(1949, 1956), 1963–64	(12)
61·2935	336·3186	139·0652	—		6	1970 May 23–June 6	(17)
178·8357	141·4087	16·6776	70 May	14·0	*p**	1923–. . .–1964	(18)
172·2479	92·7841	22·3226	70 Aug.	2·0	*p*	1939, 1945, 1951, 1964	(19)
196·2506	163·2468	14·0424	70 Aug.	2·0	*p*	1936 Sept. 9–Nov. 5	(20)
318·5494	292·9646	60·7807	—		28	1970 Oct. 20–Nov. 16	(21)
162·7627	120·3849	4·7241	70 Oct.	21·0	*p*	1958, 1963–65	(22)
198·194	291·187	4·092	—		59	70 Dec. 27–71 Mar. 27	(23)
115·6884	187·8938	2·8619	70 Aug.	2·0	*p*	1941 July 24—Oct. 20	(24)
96·5818	21·0005	126·7143	—		70	1970 July 5–Oct. 6	(25)
185·9383	334·2224	11·9749	71 Jan.	9·0	*p**	1947, 50–51, 53, 57	(26)
185·9432	334·2185	11·9740	71 Jan.	9·0	*p**	1927–. . .–1967	(27)
348·8410	2·1491	12·5275	71 Feb.	18·0	*p*	1948–49, 1955–57	(28)
328·9367	121·5554	17·8336	71 Mar.	30·0	*p*	1951, 1958, 1963	(29)
187·0146	254·2008	18·4342	71 Sept.	6·0	*p**	1951–52, 57–59, 64–65	(30)
49·7065	134·7414	11·4811	71 Sept.	6·0	*p*	(1949), 1959–60	(31)
49·7341	134·7352	11·4774	71 Sept.	6·0	*p*	(1949), 1959–60	(11)

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(18) Marsden, B.G., 1969. *I.A.U. Circ.*, No. 2191. Perturbations by Mercury to Pluto. $\Delta T = - 0^d{\cdot}02$.

(19) Marsden, B.G. & Aksnes, K., 1969. *Handb. Br. astr. Ass.* for 1970, 68. Perturbations by Mercury to Pluto. $\Delta T = + 0^d{\cdot}01$.

(20) Marsden, B.G., 1970. *I.A.U. Circ.*, No. 2277. Perturbations by Mercury to Pluto. The closest of five predictions; ΔT is small.

(21) Seki, T., 1971. *I.A.U. Circ.*, No. 2302. 3 normals.

(22) Sitarski, G., 1968. *Acta astr.*, **18**, 155. Perturbations by Mercury to Neptune. $\Delta T = - 0^d{\cdot}08$.

(23) Seki, T. & Hurukawa, K., 1971. *I.A.U. Circ.*, No. 2321.

(24) Marsden, B.G., 1970. *I.A.U. Circ.*, No. 2222. Perturbations by Mercury to Pluto. $\Delta T = - 0^d{\cdot}1$.

(25) Marsden, B.G., 1970. *I.A.U. Circ.*, No. 2281.

(26) Bokhan, N.A., 1970. *Kiev Komet. Tsirk.*, No. 103. Perturbations by Mercury to Neptune. $\Delta T = + 0^d{\cdot}06$. An earlier prediction, on *Kiev Komet. Tsirk.*, No. 81 (1969), required $\Delta T = + 0^d{\cdot}02$.

(27) Marsden, B.G., 1970. *I.A.U. Circ.*, No. 2244. Perturbations by Mercury to Pluto. ΔT is very small.

(28) Merzlyakova, M.A., 1968. *I.A.U. Circ.*, No. 2120. Perturbations by Venus to Pluto. $\Delta T = - 0^d{\cdot}1$.

(29) Marsden, B.G., 1970. *I.A.U. Circ.*, No. 2248. Perturbations by Mercury to Pluto. ΔT is very small.

(30) Sitarski, G., 1970. *I.A.U. Circ.*, No. 2257. Perturbations by Mercury to Neptune. $\Delta T = - 0^d{\cdot}01$.

(31) Milbourn, S.W. & Lea, G., 1970. *Handb. Br. astr. Ass.* for 1971, 71. Perturbations by Venus to Neptune. $\Delta T = + 0^d{\cdot}04$.

CORRIGENDA

1967 report, *Q. Jl R. astr. Soc.*, **9**, No. 3 (1968):
Page 315, line 8 from foot. For 351·5027 read 350·5027.
1968 report, *Q. Jl. R. astr. Soc.*, **10**, No. 3 (1969):
Page 253, line 15 from foot. For 61·2541 read 61·2534.
Catalogue of Cometary Orbits 1960, *Mem. Br. astr. Ass.*, **39**, No. 3 (1961):
Page 6, No. 23. For 0·622 read 0·42.
Page 7, No. 41. For 166·68 read 164·68.
Page 9, No. 57. For Oct. 19·832 read Oct. 18·832.
Page 9, No. 68. For 107·1672, 53·5694 read 107·1676, 53·5838.
Page 9, No. 70. For 287·4246, 80·2995 read 287·4248, 80·3114.
Page 11, No. 86. For 285·306 read 285·320.
Page 12, No. 111. For 301·5076 read 301·6506.
Page 13, No. 120. For B·0 read A·5.
Page 14, No. 136. For 159·1669 read 159·2182.
Page 16. No. 156. For Jan. 2·4187, B·2, 218·1223, 0·907089, 0·745539, 6·73044 read Jan. 3·7652, ($\Delta T = -1{\cdot}35$), 218·0981, 0·907108, 0·745495, 6·72888.
Page 16, No. 157. For 1·0, (blank) read 1·010182, − 0·0094112.
Page 18, No. 187. For 217·4510, 146·4401 read 217·4379, 146·4402.
Page 18, No. 189. For 199·1806 read 199·3473.
Page 25, No. 284. For June 16·06100 read June 16·56100.
Page 32, No. 383. For − 0·0004778 read − 0·0004771.
Page 33, No. 398. For + 0·0000102 read + 0·0001021.
Page 33, No. 399. For Aug. 20·44*p* read Aug. 17·83*p*.
Page 35, No. 427. For July 12·675*p* read July 12·619*p*.
Page 35, No. 430. For Apr. 13·53900 read Apr. 13.88995.
Page 43, No. 534. For ($\Delta T = +0{\cdot}04$) read ($\Delta T = +1{\cdot}2$).
Page 44, No. 547. For 1·582288, 0·558646 read 1·582143, 0·558686.
Page 44, No. 548. For 19·7123 read 19·7169.
Page 45, No. 568. For ($\Delta T = +0{\cdot}44$) read ($\Delta T = -0{\cdot}06$).
Page 46, No. 587. For 224·7766, 108·9540 read 224·7765, 108·9401.
Page 49, No. 627. For May 18·3030 read May 18·8030.
Page 49, No. 630. For Feb. 28·26219 read Feb. 27·73781.
Page 61, No. 651. For + 0·0028758 read + 0028739.
Page 52, No. 664. For 329·0975 read 329·0836.
Page 52, No. 670. Delete *E*. For 85·3286, 256·8624, 94·5188 read 85·3285, 256·8618, 94·5174.
Page 54, No. 691. For 280·1413, 254·2932, 156·5093 read 280·1397, 254·3616, 156·5092.
Page 54, No. 696. Delete *E*.
Page 55, No. 701. Delete *E*.
Page 60, No. 772. For 357· 2280, 122·1855, 116·1581 read 357·2275, 122·1295, 116·1584.
Page 60, No. 775. For 6·686164 read 6·686804.
Page 68, No. 68. Delete [Eq. 1608·0].
Page 68, No. 86. Delete [Eq. 1696·0].

B.G.MARSDEN