PART 10: EXAMPLES AND APPENDIX

1. Meteor showers of particular interest for photographic work

There is a working list of meteor showers established by the *IMO*'s Visual Commission. It gives activity and radiant data for meteor showers throughout the year. The list includes both well known showers and minor and suspected showers. All these are of interest for photographic work. During a major shower we may obtain data about radiant details or, in the case of meteor storms, about number densities as described in section 8 of Part 1 (pp. 22–23). On the other hand, the minor shower radiants are unknown to a certain extent. The determination of shower radiants requires precise postional data of individual meteor trails. Here the photography clearly allows more reliable investigation than visual material. The procedure worked out for visual data (Arlt, 1992) can be applied to photographs as well. Visual studies such as *IMO*'s Aquarid project (Koschack and Rendtel, 1991; Arlt *et al.*,1992), allow only restricted conclusions because of the limited plotting accuracy of visual observers (Koschack, IMC Proc. 1991). Hence video and photographic work may contribute very much to our knowledge about radiants of minor showers. More important, double station observations allow orbit determination of these meteoroids. In the case of low activity the number of photographically observable meteors requires data collection over many years until the existence and position of a radiant can be confirmed or excluded. Therefore, Your contributions are welcome.

The list given at the next page (Table 10-1) contains both data about major showers and minor showers that require confirmation. For radiant determination a field in about 40° to 60° distance from the radiant is recommended. In this case the trail length is not too short, and the angular velocity is still relatively small. All observations should be done with rotating shutters in order to allow a shower association. Double-station work does give the most valuable data about the radiant as well as the atmospheric trajectory, and together with the shutter breaks, also the meteoroid's initial orbit.

The given radiant list is meant for a choice of target for different kinds of observations as described in the Handbook, like radiant determination, activity analysis, photometric studies, train photography, etc. As it was the case with the visual Aquarid project, there will be also projects for photographic work initiated by the *IMO*'s Photographic Commission for other than the radiants listed in Table 10-1. Such projects will be published in the Journal of the *IMO, WGN*.

Of course, there are no periods to be emphasized for fireball patrols, as the bright, meteorite-like events are not related to known showers. Fireball patrols need to be run throughout the whole year.

Table 10-1: List of meteor showers selected from the *IMO* working list. It includes the major showers as well as some minor showers that are known for bright meteors (marked with an asterisk $*$), or for which radiant and orbital data are urgently needed (marked with a dot $\bullet$). Meteors of the showers marked with a dagger † are known for displaying trains.

Shower	Activity period (visual)	Peak	Radiant α	δ	Diurnal $\Delta\alpha$	Drift $\Delta\delta$	v_∞ km/s	Remark
Quadrantids	Jan 01–05	Jan 03	230	+49	+0.4	–0.2	41	
Lyrids	Apr 16–25	Apr 22	271	+34	+1.1	0.0	49	†
η-Aquarids	Apr 19–May 28	May 04	336	–02	+0.9	+0.4	66	†
α-Capricornids	Jul 03–Aug 19	Jul 29	307	–10	+0.9	+0.3	23	$*$
Aquarid complex	Jul 15–Aug 28	Jul 28	339	–16	+0.7	+0.2	([1])	$\bullet$ ([1])
Perseids	Jul 17–Aug 24	Aug 12	46	+58	+1.3	+0.1	59	†
κ-Cygnids	Aug 03–31	Aug 18	286	+59	+0.3	+0.1	25	$*$
α-Auriguds	Aug 24–Sep 05	Sep 01	84	+42	+1.1	+0.0	66	
δ-Aurigids	Sep 05–Oct 10	Sep 09	60	+47	+1.0	+0.1	64	$\bullet$ †
S. Taurids	Sep 15–Nov 25	Nov 03	50	+14	+0.8	+0.2	27	$*$
N. Taurids	Sep 15–Nov 25	Nov 13	60	+23	+0.9	+0.2	29	$*$
Orionids	Oct 01–Nov 07	Oct 21	95	+16	+0.7	+0.1	66	†
Leonids	Nov 14–21	Nov 17	152	+22	+0.7	–0.4	71	†
Geminids	Dec 07–17	Dec 14	112	+33	+1.0	–0.1	35	$*$
Coma Berenicids	Dec 12–Jan 23	Dec 19	175	+25	+0.8	–0.2	65	†
Ursids	Dec 17–26	Dec 22	217	+75	0	0	33	

([1]) There is an activity from the Aqr-region between beginning of July until mid-September. Usually this is described to consist of four radiants being the Southern and Northern δ-Aquarids as well as the Northern and Southern ι-Aquarids. Their activity periods and radiants are discussed in connection with the *IMO's* Aquarid project (Koschack, 1991; Koschack *et al.*, 1992). The respective meteoroids do belong to different streams. Their atmospheric entry velocities vary from $v_\infty = 31$km/s (N. ι-Aqr) to $v_\infty = 42$km/s (N. δ-Aqr). Together with the close position of the radiants, meteors of the four showers are not distinguishable by visual observations. Here, photographic work clearly can help to answer open questions.

References and bibliography:

Koschack R., Rendtel J., 1991: Aquarid project 1989. *WGN* **17**, 90–92.

Koschack R., 1992: An analysis of visual plotting accuracy and sporadic pollution, and consequences for shower association. *In: J. Rendtel and R. Arlt (eds.), Proceedings IMC 1991, Potsdam.*

Arlt R., Koschack R. and Rendtel J., 1992: Results of the *IMO* Aquarid project. *WGN* **20**, 114–135.

The *IMO* Shower Calendar. *Edited annually by A. McBeath, IMO_INFO 2.*

2. Photograph section

There are many effects described in the text which may occur on meteor photographs. In order to give you more than just a short written description, we think some real examples may be helpful for identifying meteors as weIl as artefacts or trails with other origins on your images. You will easily note that the long-exposed fireball patrol photographs show the most unusual features. Also it is often unknown at what time these phenomena appeared since no visual observer was outside at the same time, while photographs dedicated to faint shower meteors are mostly carried out if a visual observer is also active.
Such unusual features may be caused by different sources of light, for example:

- satellites
- airplanes
- lightning
- diffuse phenomena: noctilucent clouds (NLC), aurorae, other questionable spots (incidentally-caught persistent train of a fireball appearing before the start of observations), haloes (lunar light pillars, parhelia)
- artificial lights: reflections from street lamps, reflections inside the optics (preferably wide angle or fish eye lenses) with often curious shapes, flash lights or car lights, and even cigarettes.

To each example we also give some background information as well as data of the event and the used equipment, if known. In most cases we mention the local zonal time instead of UT and the latitude of the site. This allows to easily get an impression about the conditions, for example the depression of the Sun or the status of twilight.

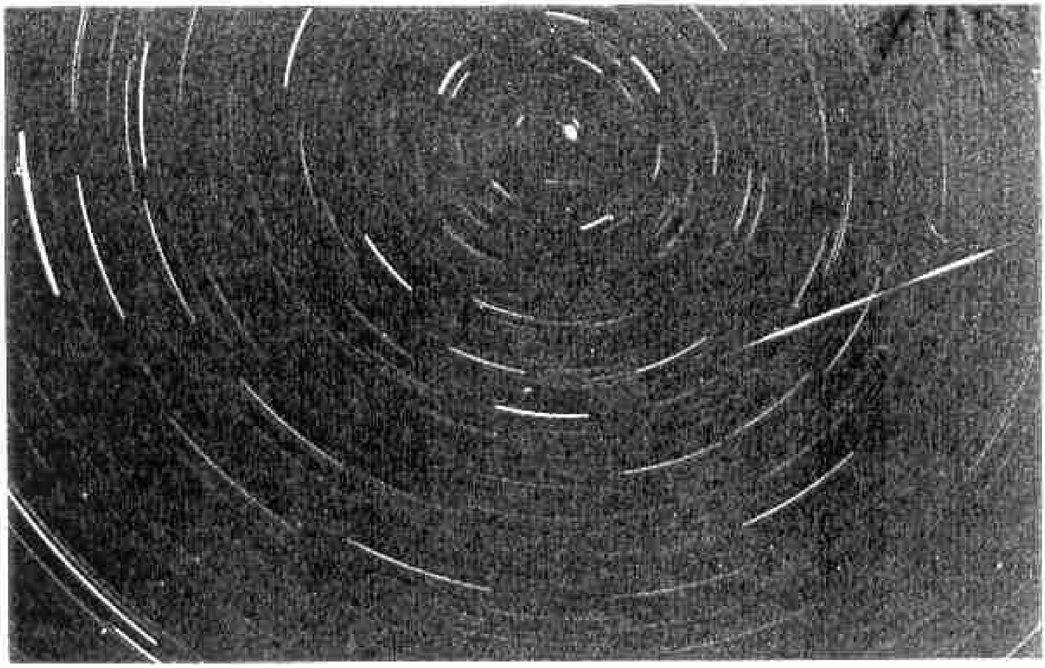

Figure 10-1: Satellite trail near α UMi in Cam. This satellite reaches a peak brightness of about -2^{m} and regularly appears in the shape shown here for observers in mid-northern latitudes: two magnitude maxima, divided by a somewhat fainter section. In this case a fish-eye lens f/3.5, f = 30 mm was used and the entire trail is visible, but if the field is smaller and no shutter allows a check of the angular velocity, the photographer might suspect a meteor had been photographed.
(1993 January 03, $05^{h}28^{m}40^{s}$–$06^{h}45^{m}10^{s}$ Local Time at $\phi = 52.4°$ N; J. Rendtel, Potsdam, Germany.)

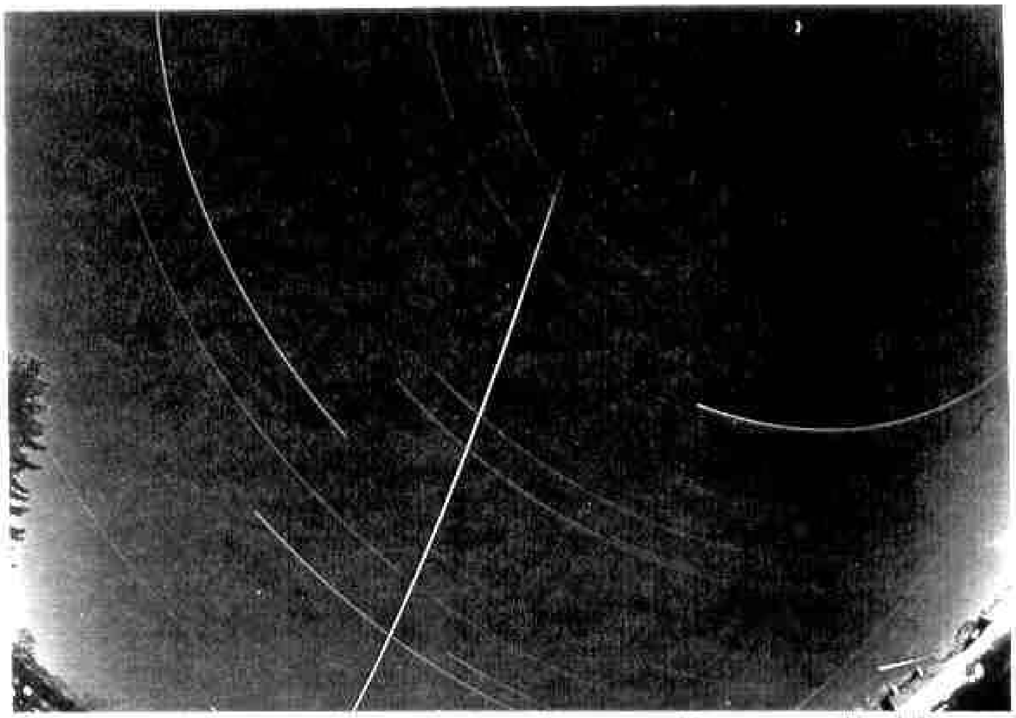

Figure 10-2: Airplanes flying at rather low elevations when approaching airports. The different lights may cause a broad variety of trails on fireball survey photographs. Often the planes fly with intense lights as in the case shown here. Again, a fish-eye lens f/3.5, f = 30 mm was used. A shutter may clarify most situations, but planes also often appear as double or multiple tracks.
(Photo taken in Potsdam near Berlin with its three airports; J. Rendtel, Potsdam, Germany.)

Figure 10-3: If broken or diffuse clouds are present, the illumination effects can vary more. This example apparently shows a trail which seems to be of a slow moving fireball (a shutter with 12.5 breaks per second was in operation during the exposure). But in fact it is the trail of the planet Venus being accidentally interrupted almost regularly by the fast moving clouds!
The other "trail" is caused by an airplane just illuminating low clouds with its landing spotlights. The diffuse clouds present also cause the lack of star trails on this image.
(1993 January 25, $17^h46^m18^s$–$18^h21^m27^s$ Local Time at $\phi = 52.4°$ N; J. Rendtel, Potsdam, Germany.)

Figure 10-4: Lightning on meteor photographs will certainly be a rare phenomenon since you are hardly likely to be hunting meteors during thunderstorms! However, in the course of a night, a camera from a fireball survey network may be surprised by lightning. In nearly all cases this should not cause identification problems because of of the irregular shape of the "trail". If a smaller field is covered only, lightning near the edges may lead to difficulties. A shutter, of course, clarifies the situation.
(1990 August 29–30, $20^h37^m55^s$–$03^h30^m30^s$ Local Time at $\phi = 52.4°$ N; I. Rendtel, Potsdam, Germany.)

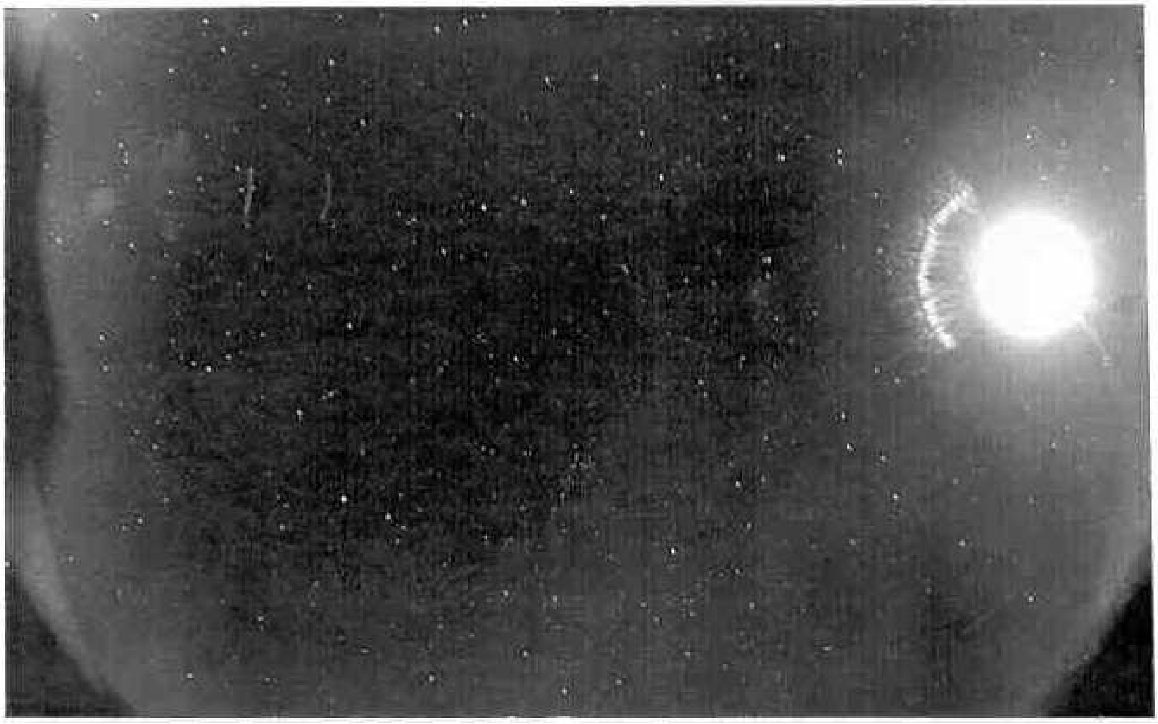

Figure 10-5: Reflections in the optics of an objective lens, especially common in wide angle or fish-eye lenses, may lead to "mysterious" features if bright light sources are to be seen. These light sources need not necessarily be in the field of view of the camera. In the example shown here, the vaning moon in the east caused a series of linear features and other figures through a fish-eye lens f/3.5, f = 30mm. The shape of such features depends on the construction of the lens.
(1988 April 23, $21^{h}O3^{m}$–$21^{h}56^{m}$ Local Time at $\phi = 52.4°$ N; J. Rendtel, Potsdam, Germany.)

Figure 10-6: Diffuse phenomena surely will not be mixed up with meteors you might think. Nevertheless, the photographer might wish to know what caused certain features. Here we show an aurora which occurred on 21st October 1989 during an Orionid watch.
(1989 October 21, $20^{h}30^{m}$–$20^{h}37^{m}$ Local Time at $\phi = 52.4°$ N, using a fish-eye f/3.5, f = 30mm and ISO 400/27° film); J. Rendtel, Potsdam, Germany).

Figure 10-7: Another phenomenon covering large portions of the sky may occur in the summer nights between $\phi = 50 \ldots 60°$ in both hemispheres: noctilucent clouds. They occur at ≈ 83 km elevation and are lit by the Sun during twilight. Their periods of visibility are shown in Figure 4-1. Dust or smoke trains may be expected to appear bright against the sky background during roughly the same periods because they occur at comparable elevations. (1988 July 03, around $22^{h}30^{m}$ Local Time at $\phi = 52.4°$ N, using a fish-eye f/3.5, f = 30 mm and ISO 100/21° color slide film which was exposed for 12 seconds; J. Rendtel, Potsdam, Germany)

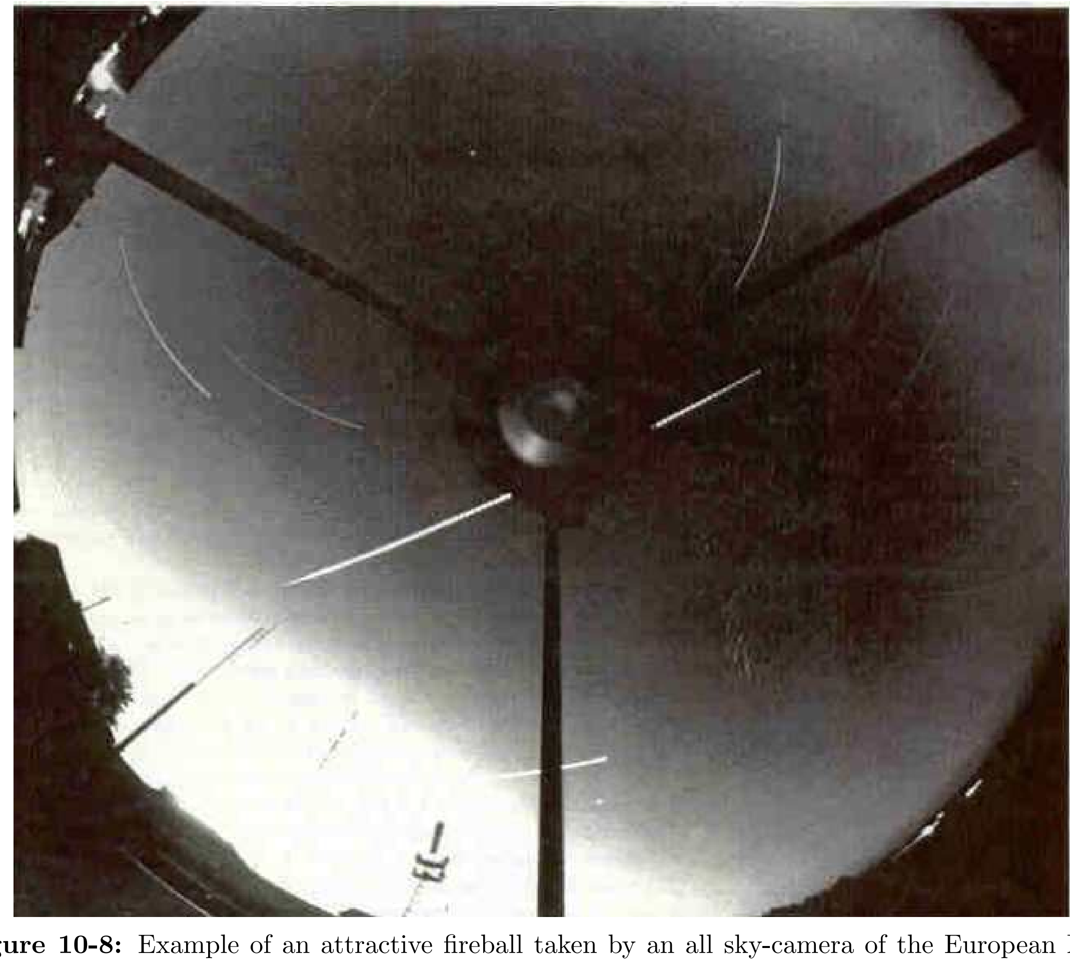

Figure 10-8: Example of an attractive fireball taken by an all sky-camera of the European Network. Note that the zenith is covered by the camera and also the camera holder obstructs large parts of the sky. The photo was exposed at the station #46 Glashütten ($\phi = 49.9°$ N) of the German part of the European Network on 1974 August 30, between $01^{h}25^{m}$ and $03^{h}44^{m}$ Local Time. (Photo kindly provided by Dieter Heinlein.)

Figure 10-9: Another example of an attractive fireball, taken through a fish-eye lens f/3.5, f = 30 mm in Lardiers, Southern France, during an Orionid campaign.

Exposed on 1990 October 21, $19^h49^m02^s$–$21^h03^m50^s$ Local Time at $\phi = 42°$ N using an ISO 400/27° -film and a rotating shutter which produced 12.5 breaks per second. However, the shutter blades of only 60° width caused too short breaks, and the breaks were exposed by the enormous overexposure due to the slow-moving -10^m fireball which terminated at the horizon. The fireball appeared at $20^h52^m14^s$ Local Time.

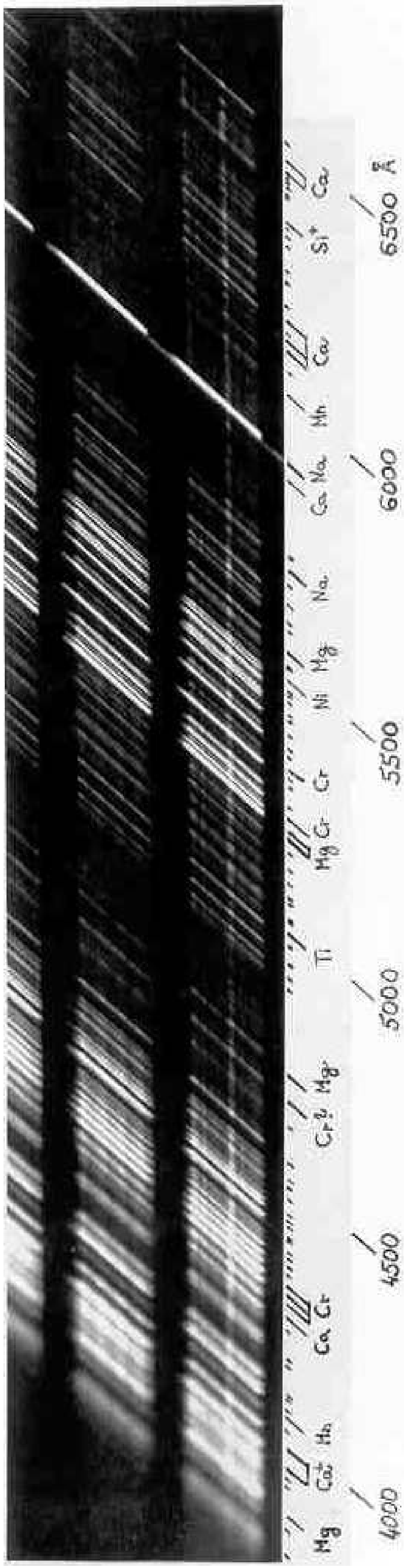

Figure 10-10 and 10-11 (next page): This is one of the world's best resolved meteor spectra obtained and kindly provided from the Ondřejov Observatory, Czech Republic by Jiři Borovička.

The fireball "Čechtice" was photographed on 1968 October 15, 19^h53^m UT, at the Czech station Ondřejov of the EN. The sporadic fireball entered the Earth's atmosphere at 19 km/s. The recorded beginning height of the luminous trail was 72 km, the luminous end height was 30 km. The fireball's maximum absolute magnitude was -9^m.

The spectrum was obtained with a f/4.5, f = 360 mm lens, used with an objective (transmission) grating with 600 grooves/mm on an ISO 400/27° plate of 18cm x 24cm size. A rotating shutter caused 15 breaks/second. Line identifications and wavelengths are given in the detail image (Fig. 10-10). The resolution is as high as 45Å/mm, and the covered spectral region ranges from 3600Å to 6600Å.

The wide-field copy (Fig. 10-11) shows a part of the zeroth order (top left) , the first order (at heights 53-34 km) and a part of the second order (right). The fireball flew from the top to the bottom. Note the meteoroid's splitting: at the bottom.

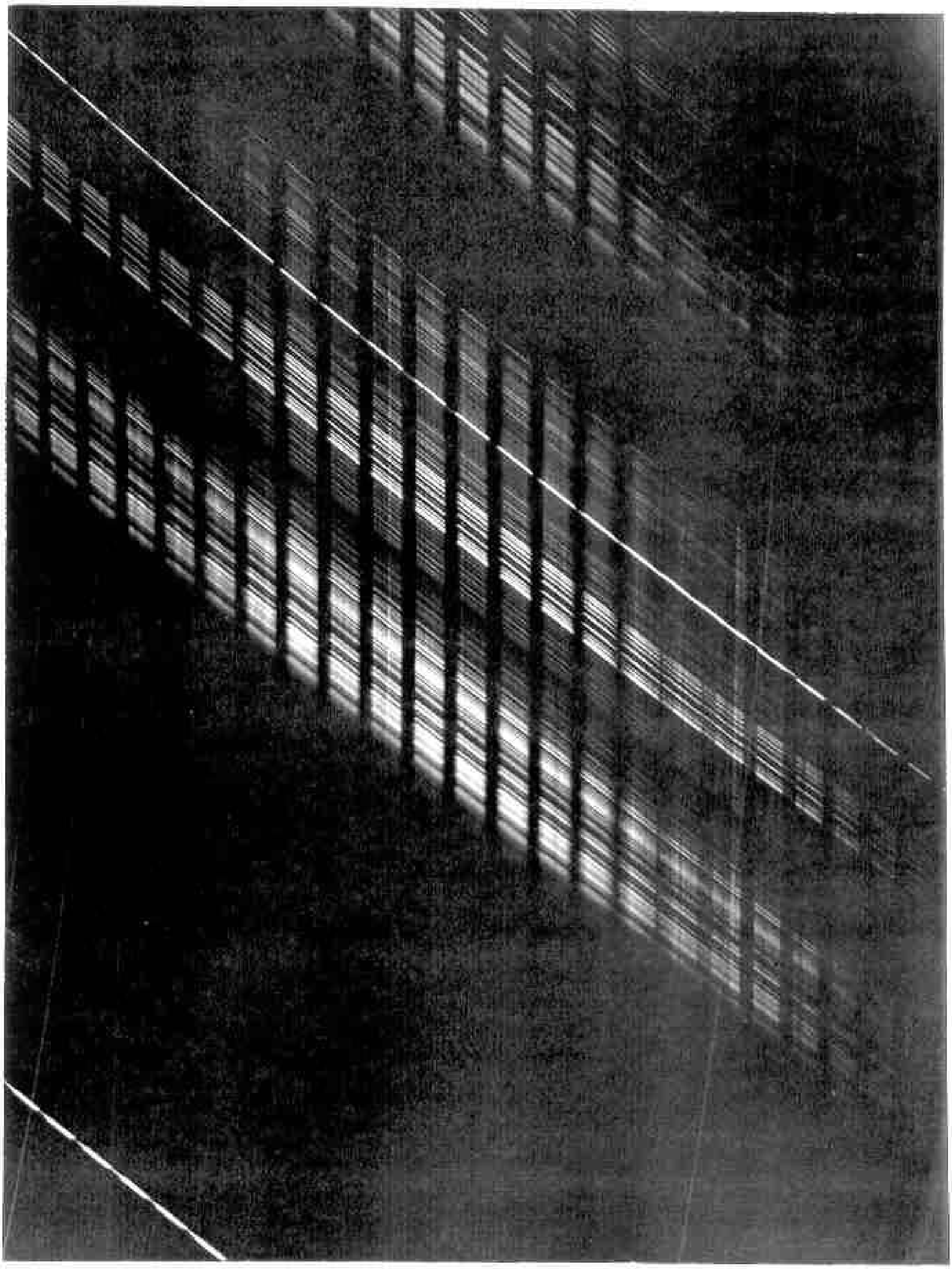

Figure 10-11: see caption on page 101.

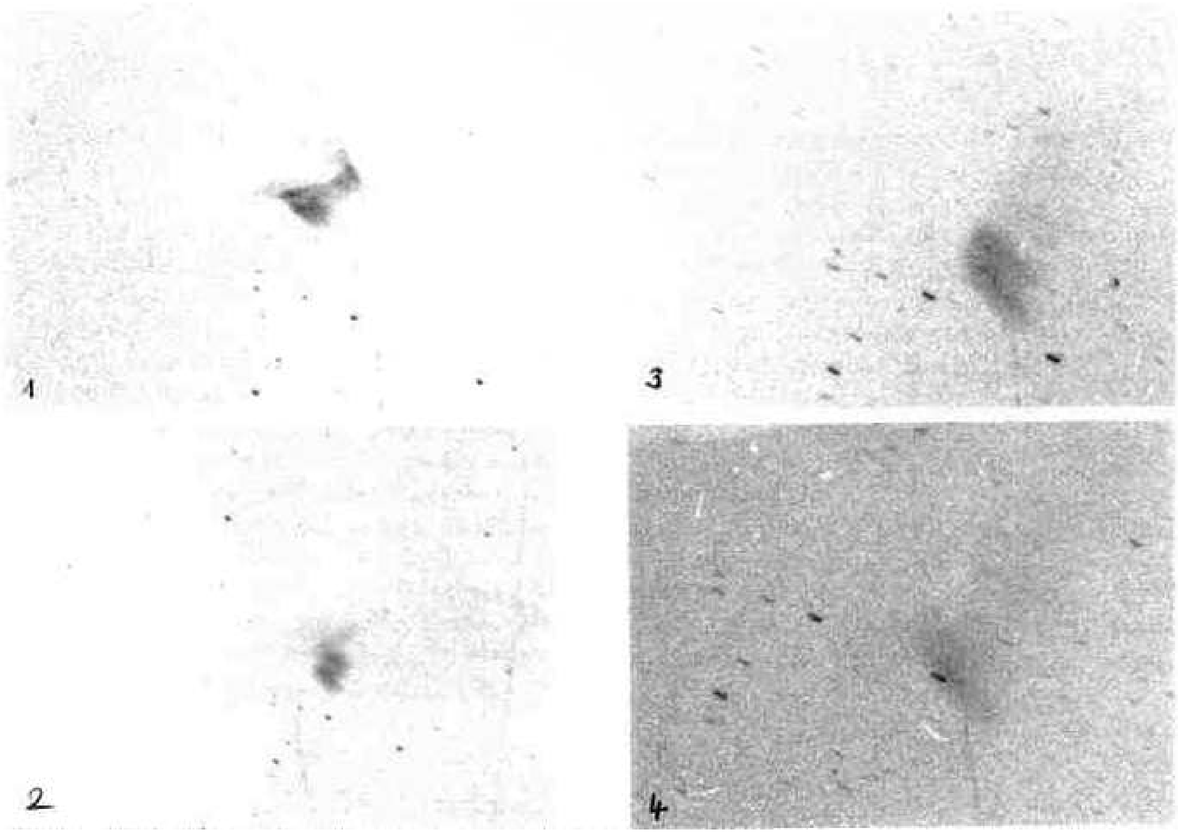

Figure 10-12: Persistent trains may be expected after the appearance of very bright fireballs. The photos shown here are part of a series taken by Karl Simmons at Jacksonville, Florida, after a Leonid fireball of -6^{m} on 1966 November 17, $05^{\mathrm{h}}05^{\mathrm{m}}$ Local Time. A fast lens with f/1.5 was used to expose an ISO 400/27° film for 10 to 25 seconds.

Figure 10-13: Smoke train illuminated by the Sun during twilight observed at the Amur River (Khabarovsk Region, Siberia, $\phi \approx 50°$ N) on 1982 October 7. (Photo kindly provided by Alexandra Terentjeva)

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- Alexandra Terentjeva of Russia (the twilight smoke train)

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Same more people also read parts of the manuscript and contributed to the final text. From this you see, that the Photographic Handbook may be regarded as a result of IMO members from many countries and we hope it is valuable for your practical work.

Potsdam, June 1993.