PART 2: FIREBALL PATROLS

1. Introduction

Fireballs are rare phenomena. Analysis of more than 5000 hours of visual observations suggests a mean annual rate of one sporadic meteor brighter than 0^{m} every 2.7 hours and one meteor brighter than -3^{m} in about 300 hours (Rendtel, 1989). Of course, there are significantly more bright meteors concentrated within or near the core regions of meteor showers such as the Perseids or Geminids, but it is known that most meteoroids of cometary origin (and even the somewhat dense Geminids associated with the asteroid 3200 Phaethon (Halliday, 1988)) completely disintegrate before reaching about 50 km altitude. In contrast, the most interesting and dynamic events are the so-called potential meteorite-producing fireballs. These are all meteoroids entering the Earth's atmosphere at a velocity of less than about 25 km/s and reaching luminous end heights less than 25 km altitude. This group naturally includes actual meteorite falls as well (Wetherill and ReVelle, 1982). The probability of such events occurring in the evening hours is about four times greater than in the morning (Halliday et al., 1984). This is because the point in the sky toward which the Earth is moving at any moment (called the apex) culminates from a given location at 6h local time. As meteors from radiants in this part of the sky have entry velocities typically higher than in the evening sector (since we tend to encounter meteoroids "head-on") there is a dearth of meteorite-producing fireballs in the morning (Fig. 2-1).

Thus, while a higher entry velocity does imply a higher amount of kinetic energy and thus also a brighter meteor, the luminous trail starts at a higher altitude and as a result the meteoroid fully ablates at a higher altitude. Therefore we expect *more bright meteors* in the morning hours, but *more meteorite-producing fireballs* in the evening sector.

A typical event of the latter kind was the meteorite dropping fireball of 1992 October 9. Its radiant was almost on the south-western horizon and it entered the Earth's atmosphere at 19:49 local time, lasted for nearly 30 seconds and resulted in a meteorite fall at Peekskill, N.Y., U.S.A. (Brown, 1992).

The major goals of fireball photography are:

(i) the recovery of fallen meteorites

(ii) the calculation of a fireball's atmospheric trajectory

(iii) the determination of a fireball's heliocentric orbit

(iv) securing photometric information that can reveal information concerning energy transformation along the trajectory

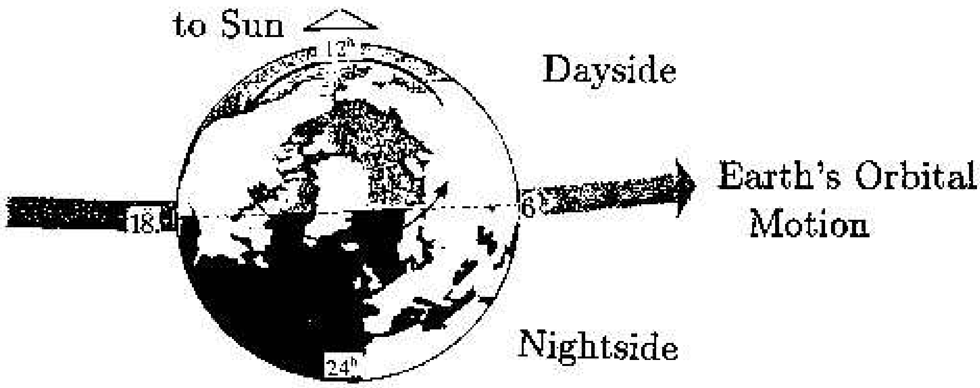

Figure 2-1: Earth's rotation and the direction of Earth's movement along its orbit. At 6 h local time an observer is situated on the "front side" of the Earth where the average collision velocity is higher than any other time during the day, while around 18 h local time meteoroids enter the Earth's atmosphere "from behind", and thus at lower relative velocities than in the morning hours.

2. Equipment

Bearing in mind the rarity of these events and the data we wish to record, the photography of fireballs, particularly of possible meteorite-producing events, requires two principal things:
– coverage of a very **large field of view**, ideally the whole sky, and
– imaging the event at a **scale** sufficient for accurate astrometric measurements.
To permit the entire sky to be imaged, the "classical all-sky camera" was invented. It uses a convex mirror with a normal camera mounted above the mirror such that the camera can photograph the whole sky (Fig. 2-2).
This has some disadvantages, for instance:
(i) the camera body blocks the zenith area (cf. also the examples given in the appendix of photographs, Part 10).
(ii) reflection from the mirror surface reduces the amount of light available for forming an image on the film in the camera and thus decreases the speed of the whole system. (A mirror that is used regularly reflects less than 80% of the incident light. The effective equivalent "speed" of such a camera system is about $f/11$.)
(iii) it requires construction of large and cumbersome apparatus to hold the camera body.
(iv) the mirror surface has to be recoated every 2…3 years to maintain acceptable reflectivity, a procedure that can be expensive.
A better alternative is to use fish-eye lenses. They overcome those disadvantages inherent in the classic "all-sky" set-up, with lenses for 6×6-cameras such as Zeiss-Distagon or the Russian Zodiak, (both $f/3.5, f = 30$mm), being of excellent quality and permitting astrometric measurements to be made down to the horizon. Ceplecha *et al.* (1979) and Ceplecha (1987) have also found that the photometric accuracy of these lenses is satisfactory over most of the visible field. But, a problem with the 6×6-camera is that it does not make use of the whole field of view presented by the lens. In general, cameras "capture" only the central part of the field that is optically available from the lens (Fig. 2-3).

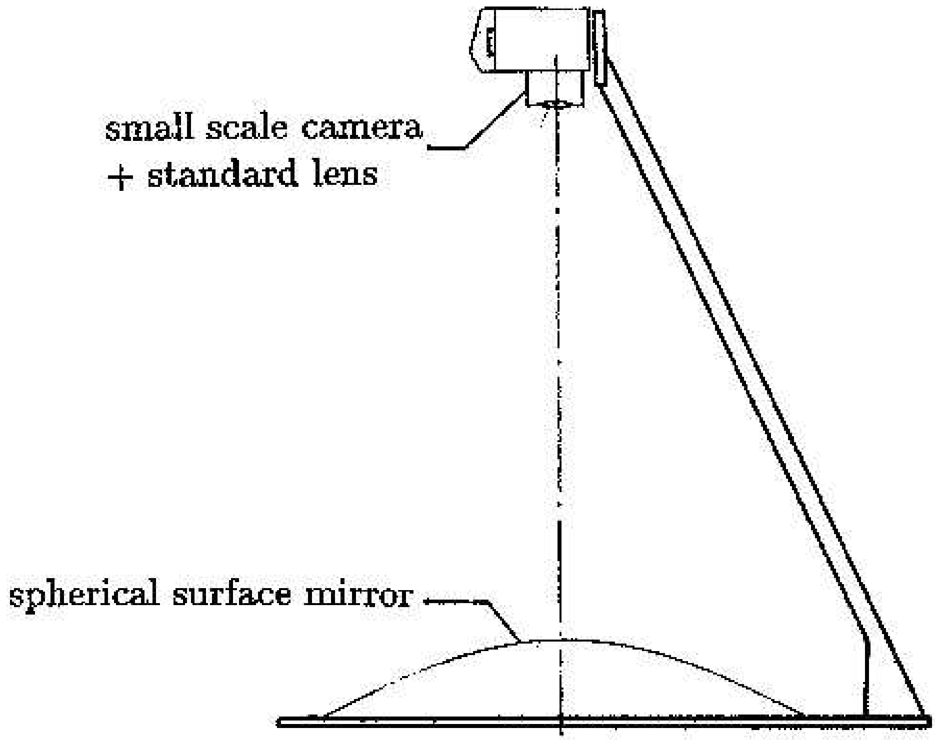

Figure 2-2: General construction of an all-sky mirror camera. The reflecting layer (usually aluminum perhaps with a protective layer of quartz) of the mirror is located on its surface. Therefore be careful to avoid scratching or touching the mirror surface. The distance between the camera and the mirror surface should be adjusted so that the whole mirror is photographed. Remember when focussing that the mirror's base is $\approx 0.8 \ldots 1.0$ m away from the camera. Here we have to focus the lens to this distance, not "∞".

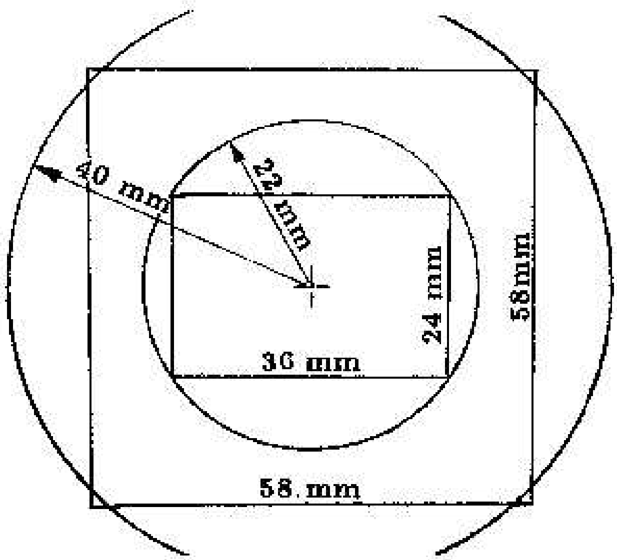

Figure 2-3: Cameras only make use of the central part of the optically available field. A good, fast lens for a camera supporting a $24 \times 36\text{mm}^2$ format may be used in combination with 6 cm format film. It requires construction of a "film-holder". Of course there is a decrease in brightness toward the limb of the field, an effect called "vignetting", which can cause problems with photometric measurements in that region. Also, the accuracy of astrometric measurements decreases with distance from the optical axis. However, this is a cheap alternative to buying a lens designed for large format films.

For example, an $f = 35$mm lens for an ordinary small frame camera produces a circular image that is larger than the $24 \times 36\text{mm}^2$ area passed through the camera body and available on the film used in such a camera. At the very least you would want to have a field of 44 mm diameter (since for fireball photography you wish to capture as much of the image from the lens as possible) with the same image quality you would expect to find within the $24 \times 36\text{mm}^2$ field. For such cameras it is in fact possible to make use of a field that is up to 60 ... 80 mm in diameter (Fig. 2-3). The amount of light will decrease toward the outer circular edge of the photo and the distortions will increase depending on the type of lens used. A 6 cm format film would be adequate to capture the full-field of such a lens. The fish-eye lens mentioned above will deliver a circular image of 80 mm diameter to the film, so we would want to use a film that is large enough to capture this full area (e.g. a $9 \times 12\text{cm}^2$ sheet). This would require the construction of a suitable "camera" box. The camera shown in Fig. 2-4 is an example that has been used successfully for several years. It also includes some additional equipment (see figure caption).

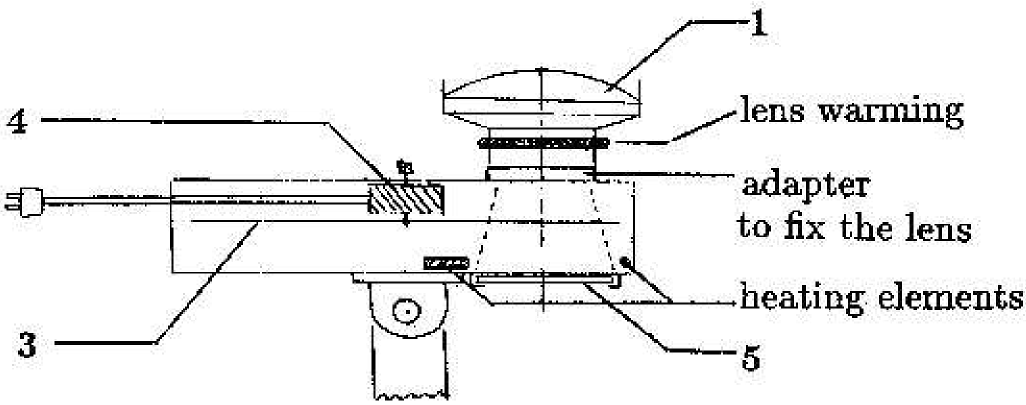

Figure 2-4: Camera-box for a fish-eye lens in combination with a $9 \times 12\text{cm}^2$ film sheet which makes full use of the 80 mm field. The construction requires a precise rectangular mounting of the lens (1) and the film cassette (5). Be careful that no stray light gets into the box. Since a shutter in front of the lens would partially obstruct the field, it can be of small size and included in the camera box, together with its motor (3, 4 respectively). More details are given in section 4 of this Part of the Handbook (pp. 30–31).

We may therefore conclude that there are two principal ways for setting up a fireball patrol – all-sky cameras (mirror cameras) or cameras with a wide-angle/fish-eye lens. The latter should be used with an appropriate film format.

If you do not have a mirror camera or a fish-eye lens, you may still meaningfully contribute to our knowledge of fireballs. Here it may be most profitable to arrange a cooperative venture with other photographers at distances of 20 ... 50 km from your site. In this arrangement a certain area of sky will be covered from all the stations to improve the odds of photographing multi-station meteors. (For details see Part 6 "Double station work".) Such networks using small frame cameras and wide-angle lenses have worked successfully in parts of Germany, for instance, for several years now. Cooperative ventures have also been successful during campaigns around the time of major shower maxima in places like the Netherlands and in Southern France.

3. Film and exposure

The choice of *film* for fireball patrols involves requirements which are very different from the case of faint meteor photography already covered in Part 1 of this Handbook. As an example, the all-sky cameras of the German fireball network (part of the larger European Network, EN) make a single all-night exposure per night. Usually, fish-eye lenses allow exposures of up to 7 hours duration in areas that are only slightly disturbed by city lights before fogging becomes a problem. Exposures of the order of several hours length are typical for fireball patrols. Bear in mind that the primary goal is not "beautiful pictures" but images that permit astrometric measurements and photometry. Again, black and white film should be used NOT color film. The reasons for this will be explained in the chapter covering photometry (Part 8 of this Handbook). Since there is no need for highly sensitive film for fireball work (as the meteors to be captured on film are so bright), the finer grain structures of slower films make this type of film the preferred choice, as it allows precise positional measurements. This increased resolution acts to offset the somewhat poor scale (ie. large scale) intrinsic to the short focal length of wide-angle or fish-eye lenses. With the combination of a lens covering a very wide field of view and a medium-sensitivity film we can reach adequate astrometric accuracy.

Table 3-1: Suitable exposure times (in hours) for a system consisting of a rotating shutter equipped with 90° wings and a lens-warming device for dark sky sites and exposure times for the same system with moonlight or other interference (given in brackets).

	all sky mirror	fish eye $f/3.5$	fish eye $f/5.6$	wide angle $f/2.8$
ISO 50/18°	>15 (10)	14 (7)	>15 (10)	11 (5)
ISO 100/21°	>15 (8)	10 (5)	14 (7)	8 (3)
ISO 200/24°	13 (6)	7 (3)	10 (4)	6 (2)
ISO 400/27°	10 (4)	5 (2)	8 (3)	4 (1)

Table 2-2: Astrometric accuracy achievable with different combinations of films and lenses (in arcmin).

	all sky mirror	fish eye $f = 30$mm	wide angle $f = 20$mm	lens $f = 35$mm
ISO 50/18°	40	1	2	0.5
ISO 100/21°	60	2	3	1
ISO 200/24°	90	3	4	2
ISO 400/27°	120	5	5	3

A photograph taken on a night with a full-moon and some haze looks terrible. In all likelihood only the trail of the moon will be recorded. If a fireball occurred, you must hope to find the start or end points of some bright star trails as reference points or make use of reference points on the horizon. In such cases, the accuracy of the position of the meteor trail decreases dramatically.

4. Additional equipment

A rotating shutter is generally of higher importance in fireball work than it is for faint meteors. For the analysis of fireball photographs, knowing the velocity of the fireball is essential and may be determined only with the help of a shutter producing breaks at regular intervals. The velocity as a function of distance along the trajectory of a bright fireball is a vital quantity that plays a role in determining the form of diverse phenomena such as the processes of energy transformation, fragmentation (due to atmospheric drag) and the fireball's (luminous) end height. The shutter also reduces the influence of any background light. The interruption frequency should lie between 8 and 25 breaks per second. Experience shows that 90°wings are most suitable for this. Except some rare very slow and/or very bright fireballs, the breaks are readily distinguishable and photometry of the visible parts of the trail is also possible using this setup. Many fireball network stations use 12.5 breaks per second that is at the lower end of the range given. The reason for this choice becomes clear when we consider that fireball patrols are designed to secure photos for meteorite-like events that should enter the Earth's atmosphere at a low velocity.

The long exposures require that the air in front of the optics is warmed. This applies equally to the large mirrors of the all-sky mirror cameras and for the large front lenses of fish-eye or wide-angle lenses.

Another effect that may cause problems is because the films, chiefly the larger formats ($6 \times 6\text{cm}^2$, $6 \times 9\text{cm}^2$ or $9 \times 12\text{cm}^2$ sheets), can spring out of focus as they cool. If you warm them a small amount, they tend to curve in the other direction (Fig. 2-5).

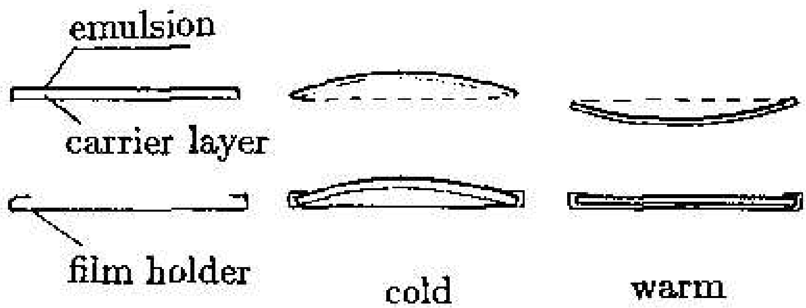

Figure 2-5: Distortion of large films due to temperature effects. The amount of curvature is strongly exaggerated for clarity.

By warming the emulsion you also reduce the Schwarzschild exponent p (cf. section 4.4 of Part 1, p. 15). While this is to be avoided in "normal" astrophotography as it makes faint objects harder to detect, this is helpful for fireball work. In our case the prominence of objects exposed for a long time is reduced (stars, background) while the short-lived fireballs are unaffected.

Another problem may arise due to the weather conditions at some sites. In general, you do not remain with your camera during the whole lengthy exposure, particularly if the moon is shining or dust and haze decrease the limiting magnitude. This leaves open the possibility that rain may suddenly occur. While clouds "only" finish the sky exposure and add background brightness (especially in streetlit areas), rain can badly affect the optics and the camera as well. In light-polluted areas you can make use of the fact that clouds, which are at relatively low altitudes, appear significantly brighter than the cloudless night sky, and thus a suitable electronic "clear-sky indicator" can be constructed. Such a device is described in detail by Mostert (1982). Although the text is in Dutch, detailed information about the electronics is given in the form of circuit diagrams. Other examples can be found in electronics magazines and journals.

In dark, non-light-polluted areas clouds appear as dark patches in the sky without any stars. Any cloud-detector must then make use of the visibility of a certain star, but to the author's knowledge such a device has not been put to use yet.

Detectors for rain and/or humidity have been constructed by different people at various times. These detectors have had a bad track record, as exposures may be finished by dew or affected by rain before the closing mechanism is triggered. Although risky, it seems the best method is to get reliable weather information (e.g. from the nearest meteorological office or an airport situated not too far away) and to make regular checks of sky conditions in questionable cases. For a privately run fireball patrol camera it does not seem appropriate to operate by the rules established by the German part of the EN that runs mirror-cameras: these are switched on every night independent of the weather …

To maintain a regular fireball patrol and to make life easier for the operators of all-sky survey meteor cameras, there are some additional tools that are easily accessible, and are also very helpful. As an example we will describe some devices and procedures developed by the EN that has been running successfully now for more than 30 years. For example, each all-sky camera operated within the German part of the "European Network of Fireball Photography" is equipped with a special closing device that is triggered by a programmable clock. These mirror cameras make **one** exposure during **each night** of the year.

To manage this properly, the tasks of the operators are

(a) to transport the film

(b) to set the time for the next night's exposure

The clock switches on the camera via a magnetic coil that moves a wire release. The camera is then kept open until the end of the scheduled interval.

5. Cleaning of the optics

If you use your camera regularly for fireball patrol work lasting the entire night it will become wet due to rain at some point. Also, you will find that more and more dust accumulates on the front lens after several hundred hours of use. At this point the front lens has to be cleaned *carefully.* We place great stress the last word of this sentence! Camera optics are covered by thin protective layers to reduce reflections (which is why they appear metallic-brown in reflected light). These layers are very sensitive to scratches. Some small grains that have collected on the lens could be silicates, and thus of comparable hardness to the glass itself and certainly far harder than the protective layer. Besides damage to the reflection-reducing layer each scratch increases the amount of stray light entering the camera. These are the reasons for being extremely careful when cleaning the lens. As a rule, a small amount of dust on the front lens has less effect than any scratches.
However, from time to time you must clean the optics. You should do this immediately after your lens has been in the rain since you will find the task much more difficult after drying has hardened the wet dust coating onto the lens.
Presented here is a cleaning method that has been used safely for many years. First, use a soft brush (hair-pencil) that is specifically designed for the cleaning of optics to remove the larger grains. Next wipe very gently with cotton-wool and pure alcohol. Use each cotton-wool swab only once to lift away the particles from the lens. After doing this until no particle deposit is visible, you will see a surface that looks smeared and inhomogeneous. As the alcohol vaporizes, the lens will cool slightly. Next, take another fresh, dry swab, breathe onto the lens and wipe the moisture away applying gentle pressure. This has to be repeated until, once again, the whole lens looks clear and homogeneous.
As already pointed out, this should be done only with care and only when absolutely necessary (after about half a year of operations, following a rain or until the first accident).
If in any doubt, consult a specialist in this field. A good camera shop can provide advice on lens care. In principle these hints are also valid for cleaning the large surfaces of the mirrors used in the all-sky camera. If no protective layer has been placed on the mirror, however, you may remove portions of the reflecting layer and thus seriously damage the mirror. This may require a new aluminization, which requires a special vacuum device and is expensive. Again, if you are unsure how to proceed contact an optical specialist. Astronomical telescope makers may be helpful for this mirror problem.

6. Time of the fireball's appearance

Unfortunately, the photograph is unable to record the time at which the fireball appeared, but the knowledge of this precise moment is necessary for the computation of the initial heliocentric orbit. The time of appearance of a fireball is needed only for the determination of the right ascension of the radiant, not for the measurement of the trail or the reduction of the atmospheric trajectory. The radiant position is essential in determining the meteoroid's origin and is one of the most valuable aspects of fireball photography. In the evening hours there is a chance that eyewitnesses may report a bright fireball, though as the night proceeds this probability progressively decreases as does the chance that meteor observers may be outside under good sky conditions nearby.

Occasionally, however, you may be lucky and witnesses have reported the event and its time of appearance. In such a case the Fireball Data Center *(FIDAC)* of the *IMO* may be able to provide the time of the fireball's appearance.
Another possible source for the time of a bright fireball is through amateurs who have an automated radio forward scatter system. A long enduring reflection may be related to a fireball (Knöfel, 1993). For more details see the *IMO's* Radio-Handbook. Records of long enduring radio echoes are also stored in the *FIDAC* files.
If you are observing while the camera is in operation, you should set your watch to a radio time signal, the most precise of which are time signals from special stations. In most parts of Europe you may use the DCF 77 station in connection with a transmission-guided clock, while in North America the short-wave signal from the WWV time station may be employed. For other regions contact astronomical observatories in the vicinity for information or consult an almanac that annually publishes lists of suitable time signals and details of their broadcasting schedule and frequencies.
Usually, however, the fireball patrol camera operates while no observer is active, i.e., on cold winter nights, during moonlit periods, during hazy nights or when the amount of cloudiness is variable and precludes other forms of observations. A bright fireball causes a large portion of the sky to be illuminated. Often its brightness increases to a certain level and in the middle and latter portions of its luminous trajectory intense flares occur. These sudden increases in brightness may be used by timing devices. Actually, there are only few such devices in use (Mostert, 1982). Their light sensitive receiver can be either a photomultiplier, a photodiode or a phototransistor. For these devices the sensitivity must be regulated in such a manner that the normal sky brightness (perhaps plus moonlight or terrestrial light sources nearby) does not produce a signal. Any additional light exceeding this threshold intensity, which is arrived at by adjustments in accordance with the local conditions and the device parameters, should give a signal and record the time of the light's onset.
These are very general remarks only. There have been several different attempts to overcome this problem, none of them entirely successful.
A general problem can occur in densely populated areas or near electric railway lines. In these regions there may be many artificial flashes that could potentially give an erroneous signal to a timing device. However, these flashes are normally of much shorter duration than those from meteors and may therefore be distinguished from bright fireball flares.
If no precise time of appearance is known for a fireball, the position in right ascension is uncertain by the angle corresponding to the duration of the exposure. For the case of all-sky or fish-eye photographs you may use features on the horizon to figure out the horizontal coordinates that will then permit the calculation of the atmospheric trajectory. But, in such cases it is impossible to find the orbit of the meteoroid and thus we cannot obtain any information concerning the origin of the particle.

7. Practical hints for patrols

Since a major goal of fireball photography is the calculation of fireball trajectories and meteoroid orbits, users of wide-angle lenses (instead of all-sky or fish-eye cameras) should contact each other to choose appropriate camera fields that intersect at the meteor level (about 80 km altitude for fireballs) and which are of comparable size at that height. Details of the calculation of double station camera fields) are described in sections 4 and 5 of Part 6 of this Handbook.
It is worth photographing even during dusty or hazy nights or when the moon is present. Although the images look terrible (from an aesthetic and photometric point of view) a very bright fireball may still be captured.
During partially cloudy periods you should survey the night sky. If there are clouds at the beginning or end of the exposure, note at least 10 stars that are not covered by clouds at these times. This will guarantee usable reference stars for astrometric measurements. If it becomes totally clear later, you may interrupt the exposure for about half a minute. The breaks in the star trails may then be used

as reference points, provided the precise time of this interruption is determined and noted.
If possible, mount your camera so that the orientation is unchanged from night to night. This will permit the determination of positions if reference stars are missing (with a strongly-reduced accuracy however) or may be helpful in identifying long star trails. For a situation where no star trails can be measured, a fixed object may be used as a reference. This could be an antenna on a roof or anything else on the image.

8. Summary of the equipment

Appropriate equipment consists of:

(1) an all-sky mirror + camera
OR a fish-eye lens + camera with suitable film size
OR wide-angle lens + camera, possibly with an enlarged film format

(2) an appropriate fixed mounting for the equipment to ensure that even strong winds do not harm the camera or alter the direction of the equipment

(3) warming devices for lens and film

(4) a rotating shutter, preferably with a synchronous motor giving about 15 breaks per second

(5) a device for fireball timings

(6) a cloud detector, perhaps with twilight dimmer-switch

(7) a timer for the beginning and end of exposures.

(5), (6), (7) are helpful, but not essential.

During the observation you should note the following information for each exposure:

(1) Precise time of beginning and end (use UT only to avoid confusion) if you use an electronic timer, check the accuracy!

(2) Sky conditions, particularly clouds at the moment the exposure starts or ends; note about 10 stars that are visible at these specific times if clouds are present.

9. Handling of the exposed films

You will not normally know which events, if any, appeared during the exposure(s) and were secured on film. You can expect some fainter meteors (about 0^{m}) to have been recorded as well as very bright fireballs. Also, the sky conditions may have been different from one exposure to the next. To permit astrometric measurements and photometry, it is best to obtain a fine grain and a smooth weak gradation (shallow slope on the characteristic blackness curve). Both goals can be achieved by using fine grain developers. A smooth and weak gradation produces sufficient density for somewhat faint meteors or the beginning of the brighter fireballs and transforms nearly the whole range of brightness into different degrees of blackening (Fig. 2-6). Sometimes, however, a large part of a fireball trail may be overexposed, or the fainter parts and / or fainter meteors do not appear on the image.

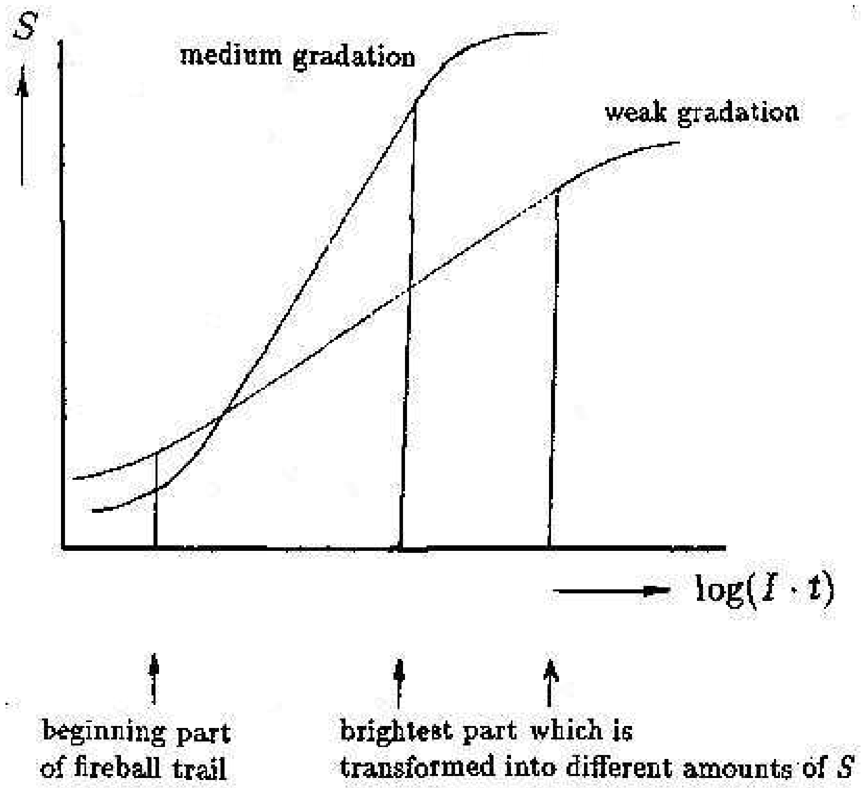

Figure 2-6: Characteristic curve for a weak gradation with the transformation of a huge intensity range into measurable differences of blackening. Although the range in S is normally larger for higher gradation, weak gradation allows better results over large intensity intervals.

Fixing is less important, but for safety fix for at least twice the time that is needed to clear the film. Otherwise, the image will not be fixed totally. Careful attention also should be taken to bathing the film in water after the processing. Half an hour usually is a recommended bathing time for images that will be stored, otherwise brownish areas may ultimately form and the emulsion can be destroyed.

10. The archive

Although the number of successful photographs from a fireball patrol is somewhat low, you should archive all negatives. If you use films such as 35mm or 60mm, they should be stored in strips whose length is determined by the size of the negative bags you can buy. Each strip has to be clearly marked to allow later identification and to avoid the possibility of mixing them up. Times of exposures and additional remarks should be noted in a file or book that is used only in connection with the fireball patrol.
If you are using single film sheets, you should write a unique identity number, the date, start and end of the exposure directly onto the film sheet (emulsion) using a permanent ink pen.
It is helpful to mark photos with fireballs in the list/book also on the negative itself, or to keep such images separately after noting that they are not included in the general stock of images. You should then also separate the data of the successful photographs.

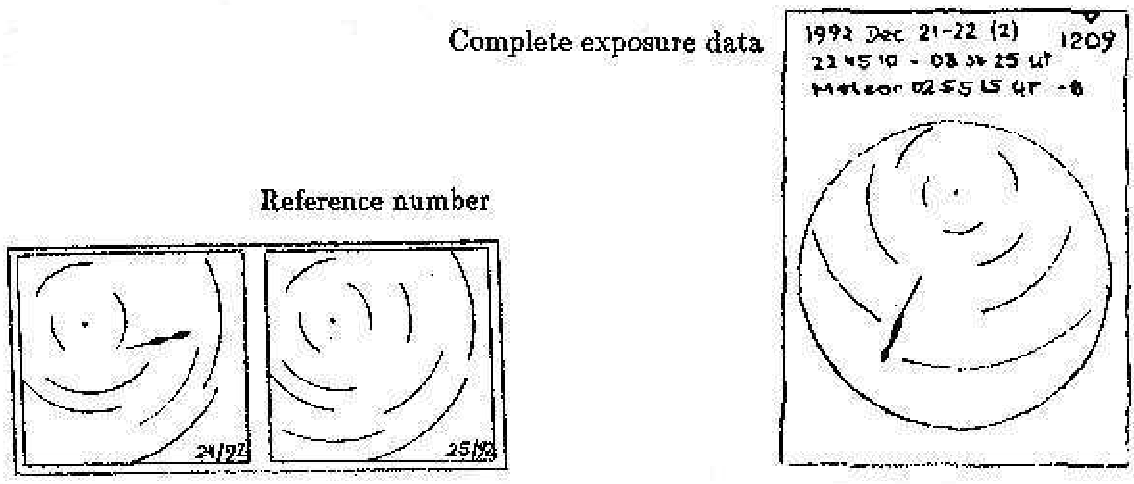

Figure 2-7: Possible identification systems applicable for fireball patrol photographs.
For 120 roll film or small scale 35 mm film the space on the negative is limited (unless you include a blank image after each night's series to include notes – a rather expensive method). A reference number will allow you to associate the notes from a notebook with the negative. Large film sheets like those used with fish-eye lenses leave enough space to note all the exposure data as well as a reference number. The diary may contain even more information about the exposure and the circumstances, e.g., about failures or unusual conditions.

As there is much trouble and money invested in obtaining each nightly patrol photo it is best to keep all the negatives, even those without any fireballs found. Occasionally it will happen that you did not see, for instance, a very short trail or a partially obstructed trail that is later detected on other photographs or reported by visual observers.
Additionally, the patrol photographs may be of interest for other events, e.g. a nova or the sudden brightness variation of variable stars that are accidentally recorded on such survey images.

11. Fireball networks

A photograph of a fireball from a single station has limited value, but it may help to improve a fireball trajectory determined from visual observations. For a meteorite fall, a single photograph may put useful constraints on the associated fireballs' trajectory. Single-station photometry (cf. Part 8) gives relative information about the brightness, but the real distance to the observer remains unknown. Calculations of the trajectory require photographs from at least two stations that are separated by several tens of kilometers. For fireball patrols it is useful to have a complete network established. Preferably the network should consist of fish-eye camera-equipped stations or all-sky cameras, but other cameras with wide-angle lenses are also possible. In the latter case, camera directions should be arranged in a certain way to guarantee that the fields of view from different stations intersect at the likely level of fireball first appearance as described in Part 6.

12. Fireballs on video

There are two spectacular fireball events which have been recorded on movie film and video respectively: an Earth-grazing fireball on August 10, 1972 (Jacchia, 1974), and the fireball associated with the Peekskill meteorite fall of October 9, 1992 (Brown, 1992). In both cases witnesses instantly used their film/video cameras to follow the fireball, and these recordings permitted further analyses of the fireball trajectory. But, both events were recorded by accident. Of course, it also would be possible to

establish a fireball patrol based on video cameras. The camera would require a wide angle lens, and somehow it must be arranged so that adequate tape is supplied for an entire night. The information about the appearance of a fireball would then be recovered from the tape, which requires either a visual inspection of the tape or a very fast computer system that can automatically search video tapes image by image for non-stellar light.
In fact, these constraints and the cost of a video-fireball patrol reduce the use of video to accidental events, particularly during daylight or twilight when photographic patrols are not active. On the other hand it also might be useful to use video cameras near the peak of major meteor showers, in this case following the hints given in section 9 of Part 1 (Faint Meteors), pp. 23–24.

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