NATIONAL NEWSLETTER

The Last Men on the Moon

During the past summer, the Apollo 15 astronauts successfully carried out man's most ambitious expedition to the surface of his nearest celestial neighbour. They conducted the most sophisticated scientific attack yet attempted on the moon's four billion year old treasure chest of rocks and soil. The men performed their tasks admirably considering the physical problems of getting to and from the moon and their survival thereon.

Manned exploration of the moon has proven (despite its incredible success) to be an exceedingly costly undertaking. Each mission in the Apollo series has a price tag of about $400 million. By comparison, each Lunar Orbiter and Surveyor cost about one tenth of that amount. The respective development expenses were of the same order.

In the early 1960's, similar comparative figures were used to suggest that robot vehicles might be more economical, since ten unmanned craft could operate in the lunar environment for the price of one Apollo. However, one must compare the worldwide psychological and historical impact of Luna 9 (the first lunar soft landing craft) and Apollo 11. Obviously the decision for a manned lunar landing had to be made sooner or later. It just happened to be sooner.

Of course there were other factors. The Soviet Union's impressive space display of the early 60's was the primary motivation. Secondly, the enthusiasm of the general public in those days far exceeds its level of today. Entering the 1970's, the Soviets are far behind in overall achievements in space exploration. With the two prime incentives of the last decade subdued, the future for man in space is clouded. This is compounded by the lack of a clear-cut role for man in future exploration beyond earth orbiting laboratories.

The advantage of sending man instead of machines alone is obvious enough today. But the era is ending. After Apollo 17 in late 1972, NASA plans no moon trips, either manned or unmanned, for at least six years. Plans for an improved version of Apollo, allowing several days for surface exploring, have been shelved and six-year-old robot moon buggy concepts are being brought out of mothballs for possible use in the 1970's. With the current trend of budget cuts, the lapse in manned moon missions will probably be ten years or longer. During this interval, the so-called Space Shuttle will be designed and built.

The shuttle concept revolves around a reusable manned vehicle, something like a small modern passenger jet. Two of these craft, it is envisioned, will ride piggyback and be launched vertically. One provides the thrust to near orbit velocity, and the second achieves earth orbit. Both sections return essentially intact and ready for another trip in a few weeks. That is the key. Nothing is thrown away as in today's boosters where all but the payload is used only once.

The shuttle idea sounds like the answer to the huge price tags of today's rare manned missions. There is an opposing view (held by this writer) that the shuttle scheme, if carried out, will become a monster ... a financial and technical nightmare similar to the supersonic transport today. A further detraction is the military implications of the space shuttle which equal and perhaps surpass the scientific objectives. The Department of Defence has set certain payload and maneuverability specifications that NASA has apparently accepted.

Prominent astronomers such as James Van Allen and Thomas Gold have called for a halt to manned space ventures. Instead of development of a new technology (the space shuttle concept) they suggest working with variations of the highly successful robots such as Surveyor, Lunar Orbiter and the Mariner planetary probes. The boosters for these packages are very reliable and exist today. Great sophistication could be achieved during this decade if the space shuttle's share of NASA's resources could be concentrated on robot technology. A recent estimate of the development cost of the shuttle suggests that it will exceed $20 billion. That is equivalent to launching several hundred Mariner class spacecraft and it far exceeds all the money now invested in unmanned space exploration.

Planetarium personnel are probably as close as anyone to public opinion about the exploration of space. Most planetarium people say the current mood is, "enough is being spent on space and more should be diverted to other, more important projects, such as pollution control and improved city management". It is futile to hope that public opinion will once again favour such grandiose dreams as the landing of the first men on the moon. The main reason for this is that no comparable goal exists. Mars may entice equal excitement if some life is detected by Viking in 1976 or by future landers. Even so, the distance and travel times involved reduce the impact of a manned mission. A further detraction is the ratio of expense between a manned and unmanned Mars landing project, which is about 100 to 1.

Without public support, massive space expenditures (like the space shuttle) are doomed to tediously long development periods. At a recent conference of planetarium personnel, the director of a large U.S. facility said that he thought Apollo was just "a flash in the pan". There was general agreement that non-military space exploration has passed its peak and will decline to a level yet to be determined.

Thus, the void after Apollo 17 certainly exists. Those astronauts will be the last men on the moon for a long time and the unfortunate fact is, almost nobody cares.

STRASENBURGH PLANETARIUM
ROCHESTER, N.Y.

TERENCE DICKINSON

Summer Lecture Series in Saskatoon

Each summer the University Campus in Saskatoon is invaded by a wave of public and high school teachers from all over Saskatchewan. These teachers come back to university to broaden their theoretical knowledge and augment their professional skills. This summer the Saskatoon Centre has conducted a series of four evenings on astronomy which were designed primarily to assist these teachers in teaching modern astronomy, by indicating to them where they may find and how they may use astronomy resource material and to discuss matters of special astronomical interest in Saskatoon. Each evening commenced with a short talk given by a senior member of the Saskatoon Centre of the Royal Astronomical Society of Canada and concluded with a "workshop-open house" at the University Observatory. While the objective of the series has been to better equip teachers to teach astronomy in the classroom, non-teachers who have attended the sessions have found them both instructive and entertaining.

The series began on July 7 with Dr. F. A. Holden, the only non-professional astronomer to lecture in the series, discussing "*The Observer's Handbook* As a Valuable Source of Astronomical Data". Dr. Holden, over the years, has won an enviable reputation as one who is able to describe in an interesting manner the most complex of concepts, in language easily understood by all. A week later Professor J. E. Kennedy, Past President of the Royal Astronomical Society of Canada, offered some useful and interesting comments on the topic "Optical Astronomy and Methods of Astronomy". This lecture, along with Dr. Holden's, was designed to provide teachers with a basic introduction to astronomy and to astronomical data.

Dr. B. W. Currie, Honorary President of the Saskatoon Centre, Royal Astronomical Society of Canada and Vice-President (Research) of the University of Saskatchewan was the lecturer on July 21. "The Earth's Atmosphere and Astronomy" was the topic of his talk. Dr. Currie discussed aurorae, noctilucent clouds, sunrise and sunset colours and the limitations placed on optical and radio observations of astronomical objects by the terrestrial atmosphere, and he illustrated his lecture with his personal slides. These slides not only effectively supplemented his lecture but also were of obvious artistic merit.

The final lecture in the series was entitled "Recognition and Scientific Value of Meteorites" and was delivered by Mr. A. T. Blackwell, who is Head of the N.R.C. Meteorite Observation and Recovery Project and Secretary of the Saskatoon Centre. Like Dr. Currie's lecture, this talk was directed towards creating an awareness of astronomical matters of particular interest to residents of Saskatchewan. Those in attendance were especially interested in Mr. Blackwell's display of meteorites.

During the winter months the Saskatoon Centre conducts a continuing project whereby resource material and lectures are provided for schools in Saskatoon and district. It was hoped that the summer series of lectures would assist areas outside Saskatoon to supplement their astronomy programs. Judging from the steady attendance at the lectures, as well as the interest shown by those in attendance, the series has been an immense success. It will certainly become an annual event in the Saskatoon Centre's calendar.

SASKATOON — LINTON SMITH

Grazing Occultations

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An "occultation shadow" can be defined by a cylindrical shadow extending from the Moon in a direction opposite to the direction towards a certain star. As the Moon moves in its orbit, this shadow may sweep across the Earth's surface, defining a large region from which an occultation of the star will be visible. Observers at the advancing edge of the shadow will see the star disappear, while those on the receding edge will see the star emerging on the other side of the Moon. At a fixed location on the Earth's surface, the occultation will generally last over an hour; that is, it will take over an hour for the shadow to pass over the location.

As one approaches the northern or southern limit of the region of visibility of an occultation, the star will appear to traverse a shorter chord behind the Moon's disk and the duration of the occultation will shorten. Within one or two miles of the predicted northern or southern limit of the area of visibility of an occultation, a *grazing* occultation, or graze, will occur. The star will appear to move along a line tangent to the Moon's disk (actually, the Moon is moving, while the star's position in the sky is relatively fixed) and will disappear and reappear several times among mountains, valleys, and craters along the Moon's edge, for a few minutes around the predicted time of "central graze".

A relatively favourable graze will be visible from a particular place only about once every ten years; for every 1000 "ordinary" or total occultations, there will be only one graze. Almost half of the grazing occultations occur entirely along the Moon's sunlit side and are therefore not observable; bright glare from the Moon overwhelms the relatively feeble light of the star. If one has portable equipment and is willing to travel to the immediate vicinity of predicted northern and southern limits, he can increase his chances for observing a graze considerably. Within 100 miles of a given location, one can expect about ten grazes visible with a small telescope to occur during a year.

Grazing occultations are interesting events to observe; at no other time, with the exception of a total solar eclipse, can the Moon's motion be more strikingly observed. Timings of the disappearances and reappearances seen during a grazing occultation are especially valuable for determining corrections to the Moon's celestial latitude (distance above or below the ecliptic), that is, whether the Moon is slightly north or south of its predicted orbit. Dozens of timings of total occultations are needed to begin to get equivalent latitude information, and they can never equal the accuracy of graze observations for the job. (Timings of total occultations are needed to observe corrections to the Moon's celestial longitude, that is, whether the Moon is slightly ahead of or behind schedule; and lasers are now used to measure accurately the distance to reflectors placed on the Moon. Grazes can not be used for these purposes.) Graze observations are also used to improve the "limb corrections", which are corrections for the heights of the Moon's mountainous surface above or below the average spherical surface based upon carefully measured photographs, and which are needed for the analysis of all occultation observations.

The usefulness of graze observations depends mainly upon knowing the accurate geographical position of the observer. The accuracy needed in timing graze events is only one or two seconds for most purposes, considerably less stringent than the accuracy sought for timings of total occultations. Making timings during a graze, when several events within the space of one minute might be timed, is perhaps most easily done with a portable, battery-powered tape recorder and shortwave radio. The observer records WWV or CHU time signals, and either voiced calls, the click of a mechanical toy "cricket", or a buzzer when the disappearances and reappearances of the star occur. After the graze, the tape is played back and the time signal seconds beats counted to get the timings of the graze events. If this equipment is not available, a stopwatch or even a wristwatch with sweep second hand can be used, with the help of two assistants, to make timings. The watch must be checked against WWV or CHU both before and after the graze, so that rate corrections can be applied (under field conditions, stopwatches usually "drift" by a few seconds over the course of half an hour, so that rate corrections are needed) to the timings. One assistant constantly observes the watch, keeping track of the time. When the observer calls out an event ("D" for disappearance, "R" for reappearance), the time keeper calls out the time, which the other assistant then writes down. Of course, there is some possibility of making an error in this system, so the tape recorder method is preferred.

Observations of a graze by one observer are very useful. However, the observations are more valuable (the accuracy of the results are improved) if two or more observers make timings at locations spaced different distances from the predicted limit (across the one or two-mile-wide predicted "graze band"), so that different depths of the graze can be observed and the actual lunar profile better traced. When possible, the observation of grazes is best done as a group project.

Detailed predictions of the geographical locations of northern and southern occultation limits are computed at the Aeronautical Chart and Information Centre, and also by a few other observers who have access to large electronic computers.

ST. LOUIS — DR. DAVID W. DUNHAM

Occultation Highlights, October-December 1971

During the last part of 1971, two passages of the Moon across the Pleiades star cluster will be visible from most of North America. These Pleiades passages will be the most nearly central ones visible from this continent since 1969. The most occultations of bright Pleiades stars will generally be visible in the middle and western parts of the continent. The Moon will be gibbous during each event, making observation of the fainter stars difficult. The November 4 event (2h to 5h U.T., Moon 97% sunlit) will be most difficult, with the Moon nearly full and only reappearances occurring on the narrow dark crescent. Most of the December 28–29 event (22h to 1h U.T., Moon 90% sunlit) will occur before sunset for the West, but observers there will be able to see the occultation of the third magnitude star Alcyone (η Tau, the brightest Pleiad) in daylight, if sky conditions are good.

The southern limit of the November occultation of Alcyone passes near Pittsburgh, Pa., Schenectady, N.Y., Charlottetown, P.E.I., and Goobies and Bay de Verde, Nfld. The southern limit for the same star in December passes near Dallas, Texas, Terre Haute and Indianapolis, Ind., Toronto and Ottawa, Ont., Quebec City and Gethsemani, Que., and Southern Arm, Nfld. Within a mile or two of the graze path, observers with telescopes will be able to see several disappearances among lunar mountains as the star appears to graze the southern limb of the Moon.

The southern limit for the October 28 occultation of θ Cap extends northeastward to Newfoundland. A graze will occur about 15 miles northwest of St. John's. A good occultation of $6^{m}.1$ ZC 3270 will occur in the Maritime Provinces on December 22, but takes place before sunset in the United States. The southern limit passes 25 miles northwest of Halifax, N.S. (22h 20m UT.) and about 40 miles south of Deer Lake, Nfld. (22h 27m U.T.). The occultation of $5^{m}.2$ o Gem by the gibbous Moon will also be visible from much of Canada on November 7. A favourable south-limb graze will occur 20 miles south of St. John's Nfld., at 7h 25m U.T.

Further information on occultations may be obtained from current issues of *Sky and Telescope*, from the 1971 Occultation Supplement, obtainable from *Sky and Telescope*, and from the *Observer's Handbook*. Detailed computer predictions of graze paths are available from the undersigned (address: 4771 S. Spring, Apt. C, St. Louis, Missouri, 63116).

ST. LOUIS — DR. DAVID W. DUNHAM

Meteor Showers

The study of meteors is a popular activity among amateur astronomers, because it requires no costly equipment. Six of the ten major meteor showers occur between Oct. 15 and Jan. 15; data on these meteor showers are listed on page 71 of the Observer's Handbook.

The following article is reprinted, with the permission of the author and the editor, from the newsletter of the Saskatoon Centre, R.A.S.C.

The radiant of a meteor is the point where the meteor's path intersects the celestial sphere, or, if you prefer, the point in the sky from which the meteor appears to come. A shower of meteors refers to an occasion when many meteors come from the same radiant. The radiant of the Perseid meteors is in the constellation Perseus, that of the Orionids is in Orion, and so on.

During a shower, a large number of meteors will be seen crossing the sky in all directions; their paths extrapolated backwards all appear to originate in a common point, the radiant. This is most clearly demonstrated if one plots the paths of all observed meteors on a star chart. If you are watching for meteors, do not think that you will do best if you watch the area near the radiant; you would actually do worse by this procedure because the meteors would be coming nearly straight towards you and would appear to cross very little sky. Whether or not there is a shower in progress, there will still be a number of sporadic meteors, that is, ones which are not a member of a recognized shower. Under the best conditions, one can see about seven sporadic meteors an hour on any night of the year. It is estimated that over the entire earth there are several million visible meteors every day.

It is possible to trace back for centuries several of the prominent showers of modern times. The Perseid shower made its imprint on history at least a dozen times between A.D. 36 and A.D. 1451, and the Delta Aquarids appear in records back to A.D. 401.

Many of the Greek and Roman writers, unhampered by scientific knowledge, were quite convinced that stones did fall from outer space, and that meteor showers were associated with something beyond the earth. In contrast, toward the end of the eighteenth century, the Academy of Science in France declared unequivocally that a meteorite, which had actually been seen to fall by numerous eyewitnesses, was merely an earthly stone that had been struck by lightning. Not until the scientist Biot carried out a careful examination of one fall of stones and proved beyond doubt that they were indeed of extra-terrestrial origin were the doubting scientists convinced of the facts that the ancient people had intuitively known.

That was in the year 1803. Interest in meteors fell off, however, because interesting events are not very frequent. It needed an amazing spectacle in the heavens to cause a resurgence of public interest and scientific investigation. This inspiring spectacle was the famous Leonid shower of 1833. On the night of November 12/13, a tempest of falling stars broke loose all over North America. From Halifax to the Gulf of Mexico, thousands of entranced observers watched as myriads of shooting stars laced across the sky and majestic fireballs lit up the ground below. Superstitious people thought the Day of Judgement had come, but the more enlightened regarded it rightly as a natural, although uncommon, event of unusual splendor. It was during this shower that scientific observers first noticed that all the meteors came from the same radiant point.

The great Leonid shower of 1833 revived memories of a similar display in 1799. Astronomers realised that this might be a periodic event, and predicted that a major Leonid shower would occur again in 1866. Sure enough, there was a magnificent display on Nov. 13, 1866. The shower came back in fair strength in 1867 and 1868, and then tapered off. Its anticipated return as a major spectacle in 1899 was widely heralded in the popular press, but there was bitter disappointment when the shower produced only a smattering of meteors. What had happened was not difficult to explain, and in fact had been predicted by one astronomer, but the explanation did little to restore the layman's lost faith in scientific predictions. The explanation was this: the orbit, which had been calculated with fair precision, had taken the stream of meteors close to Saturn in 1870 and Jupiter in 1898, and the gravitational attraction of these two massive planets had shifted the orbit to well over a million miles inside the earth's orbit in 1899. Since then, a few Leonids have been seen each year, and in the years 1932 and 1935 an appreciable increase in the rates was recorded, but the intensity was insignificant in comparison with the phenomenal displays of 1799, 1833, and 1866, and it is unlikely that we shall ever again witness the full fury of the Leonid storm.

About the middle of the nineteenth century, several eminent scientists pointed out that the orbital elements of certain comets coincided remarkably closely with those of some meteor showers. (The orbital elements are five numbers which uniquely describe the orbit of anything in the solar system; they are: the semi-major axis and eccentricity of the ellipse, the inclination of this ellipse to the plane of the earth's orbit, the ascending node, which is the place where the orbit crosses the ecliptic from south to north, and the argument of perihelion, which is the angle from the ascending node to the place where the orbit is nearest to the sun.) The orbit of the Leonid meteors was identified with that of Comet 1866 I (also called Tempel's comet). Schiaparelli (the same fellow who discovered "canals" on Mars) demonstrated the agreement between the orbits of Comet 1862 III and the Perseid meteors, despite a shortage of data. The Lyrids in April were connected with Comet 1861 I.

Perhaps the most conclusive evidence for the cometary basis of meteors was deduced from the remarkable behaviour of Biela's comet, discovered in 1826. This rather faint and unspectacular object was proved to have been seen on at least two earlier occasions, in 1772 and 1805. It reappeared in 1832, but in 1846 it was observed to have split into two parts. The pair, separated considerably, were seen again in 1852 for the last time. However, in 1872, a magnificent meteor shower occurred just as the earth passed through the comet's orbit, which strongly confirmed the suggestion that meteor showers are the debris of comets. It should be noted, however, that even before the comet divided, the Bielid shower had made several appearances. It must not be concluded, therefore, that a comet must necessarily disintegrate before a meteor shower is produced. The comets connected with the Leonids, Lyrids, and Perseids are still moving in their courses as relatively compact bodies. In the case of a very old shower like the Perseids, the particles have become fairly uniformly distributed around the orbit so that there is little difference in the intensity of the shower in different years. The younger showers, such as the Giacobinids in October, show strong concentrations near the point on the orbit where the comet is or was. In 1933 and 1946 the Giacobinids produced phenomenally high rates of 4000 to 6000 meteors per hour as seen by a single observer. However, the duration of the whole shower was only about three hours. In 1952 this shower occurred in daytime and was detected by radar, but was not spectacular; since then its activity has been negligible. The Giacobinids are particularly interesting because photographic studies in 1946 showed them to be extremely fragile dustballs, in no way resembling the solid rocks which sometimes reach the earth and are then termed meteorites. In fact, it appears that cometary meteors are, in general, rather fragile objects, and that no meteorite has ever been produced by a cometary meteor.

One should not think that all the exciting meteor showers have happened and that we shall never see any more. At any time there may be a new shower created by a new comet, or an old shower could be revitalized or a new one created by perturbations in the orbit of cometary debris due to gravitational effects of some other planet. It is impossible to predict when this will happen.

SASKATOON — ALAN T. BLACKWELL

Astronomical Serendipity

Serendipity is defined as the finding of valuable or agreeable things not sought for. The history of astronomy is filled with things serendipitous; Herschel's discovery of Uranus, Alvan Clark's sighting of the companion to Sirius, Jansky's detection of galactic radio radiation; quasars; pulsars; neutron stars. And the unexpected appearance of an aurora, or a comet, or a nova is surely a serendipitous event for the observer.

I have occasionally come across serendipitous items during my reading and while traveling. A selected half-dozen are here presented for readers of the *National Newsletter*.

In *Cloudland*. The *New York Times* reported that "astronomers now believe the rings of Saturn are predominantly water ice crystals like those in circus clouds above the earth."

Ringling Brothers, Barnum & Bailey Saturn?

Spring at Last. An item in the *New York Post* gave the extraordinary news that "the arrival of spring will be marked by the appearance of the sun over the Eqquator (sic), north of the Equator, north of the Pacific Ocean."

Near Baffling Island?

Astronomy by the Thames. A gazeteer of London streets shows that a few were named for celestial objects; Sun Street, Star Street, Star Road, Planet Street, Comet Street, Half Moon Street, and Half Moon Passage.

Half Moon Passage lies but a few blocks from the spot where Jack-the-Ripper's third victim was found.

Astronomy by the Seine. The Paris Observatory is open to visitors but one day each month, and then only upon prior written application to its Director. A tour of the Paris sewer system is given twice each week, on the other hand, and no reservations are required.

The moral, I suppose, is that sanitary engineers can have more fun in Paris than astronomers.

Those Clear Italian Skies. If you visit Venice be sure to look for a post card showing the crescent moon setting over the Bridge of Sighs. Not only are the horns pointing down, as you obviously surmised, but the direction you are looking happens to be due north.

The Good Old Days (Before Pollution). According to the *ASCAP Directory of Hit Songs*, one of the ballads most popular in 1934 was "It's Dark on Observatory Hill."

Sic Transit Gloria, as they say at Mt. Wilson.

BROOKLYN, N.Y. — KENNETH WEITZENHOFFER