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Contents

Comment	84
The Making of an Astronaut	85
A World Calendar	88
Our Galaxy	90
Greenwich Observatory 50 Years Ago	93
Spectrum	96
Comet Tails	99
The Great Discoverers	102
Galaxies and Nebulae	104
Society Notices	107
Sky Diary	108

HERMES Vol 15 no 4

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The Junior Astronomical Society
For people of all ages interested in astronomy as a hobby.
Annual subscription of 15s includes 4 issues of Hermes.
Full details may be obtained from the Secretary.

Printed by Sumfield & Day, Ltd.,
Station Street, Eastbourne, Sussex.

*COVER: Comet Burnham photographed by
M J Hendrie and H B Ridley on 1959 April 27.1
with R L Waterfield's 6-inch Cooke triplet
using an Oa-O plate. Exposure 20 minutes; the
comet is seen here at its maximum brightness
of 4.0m. The coma is about 20' in diameter,
the tail is straight and slender for 4',
then becomes more diffuse and can be traced
on the original plate to just 11° from the
head of the comet. See the article on page 99.*

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Comment

What's good and bad in the world of astronomy

Whatever happened to Europe?

THE ASTRONOMY, SPACE AND RADIO BOARD of the Science Research Council has reviewed its policies and programmes. In presenting the report publicly, Professors Hoyle and Sheppard waved their arms expansively as they reviewed past exploits and outlined new ones.

The Board is responsible for the support of university research in astronomy and space science, and for the British involvement in ESRO; it is also responsible for the Royal Greenwich Observatory, the Royal Observatory Edinburgh and the Radio and Space Research Station, Slough.

These duties the SRC took over in 1965 on the closure of the Department of Scientific and Industrial Research, which had already set quite a lot in motion; but be kind, and chalk up to the SRC one Hooray mark each for the completion of the Isaac Newton Telescope and the agreement with the Australians to build that 150-inch telescope down under. Bonus marks also for the support of Jodrell Bank and Lords Bridge (Cambridge) radio observatories, and for development of small sounding rockets of the Skylark/Skua/Petrel type.

Use of the Skylark rocket fired from Woomera has already placed Britain ahead of the world in one branch of solar research, a fact which the USA Space Science Board recognizes. What other ploys is the

SRC hoping to use to win Hooray marks and Bonus points during the coming five years?

'Top priority', they say, is being given to the development of the Skylark Stage V, a stabilized rocket suitable for obtaining emission measures from stars down to magnitude 5. Wider exploitation of the sounding rockets Petrel and Skua, as well as a successor to Ariel III, are also top of the space list.

Astronomy-wise, top marks are being sought for progress with the Anglo-Australian telescope. The mirror blank is already ordered, and tenders will shortly be invited for the figuring of the mirror, the secondary optics and the declination assembly. A large northern-hemisphere telescope is still at the hush-hush stage.

Design work for Jodrell Bank's Mark V dish will continue, although construction has been deferred. Funds to mend the 250-foot dish because it broke recently have already been offered. Lords Bridge will also get its 3-mile array of fully steerable dishes.

All this, plus developments along other more mundane lines, are being strongly backed, but ESRO-sized space exploits are being diplomatically avoided. Presumably all the other ESRO countries are doing the same, leaving the European organization with projects small enough to be handled by single countries anyway. Which of the ESRO countries is going to be first to end this diplomatic farce and throw in their lot with the Yanks?

The end of a President

ABOVE, I MENTION the Isaac Newton Telescope, the fifth largest optick tube in the world and spoken of with awe, although the usual foul rumours have been circulating as to the efficacy of its mirror surface. From photographs taken in the dome one just about gets the feeling of how stubby the tube really is, although there's no indication of the ghastly lighting like it was in a zoo's hot house. I found it a monster anti-climax to sweat up 80 steps to a badly designed viewing platform for a look at this astronomical fag-end.

However, the really important thing about the JAS trips to Herstmonceux this August was that these were the last occasions to see Michael Maunder in the capacity of President. Two years ago he came to the head of our organization almost as an outsider, although he was very active at Croydon some years back. Michael immediately took a grip on the situation and pumped into the Society a large number of benefits for all its members. This October he hands over to Peter Lancaster Brown, a world-famous astronomer who we are proud to see head our Society. Michael Maunder has set a high standard for the future; we all owe him a lot.

Small ad.

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Special Notice.

IS YOUR SUBSCRIPTION DUE THIS MONTH? If so, or even if you are not due to renew until next March, please see Society Notices on p 107.

With first flights imminent in the Apollo programme, we probe the spacemen's training schedule. A US News Team sends this report on

The Making of an Astronaut

THEY came through the glass door singly and in pairs, in the uniforms of the Air Force, Navy, and Marines and in civilian clothes. The men crowded into a conference room at the School of Aerospace Medicine, Brooks Air Force Base, Texas. All of them were the lean, spare, jet-fighter pilot types. All of them were astronaut candidates seeking a place in the space programmes of the National Aeronautics and Space Administration (NASA).

Each candidate was assigned to one of ten physicians who interviewed him in detail on his past medical history. A rigid schedule of appointments was worked out. The minute-by-minute and the inch-by-inch testing that sought to determine any hidden medical deficiency was awesome in its thoroughness.

There were psychiatric and psychological tests. The men were tilted and rotated in darkened rooms, and spun in a centrifuge so that the physicians could look at their hearts' reactions. Sketches were made, in another test, of the electrical forces pulsing through their hearts. They were submerged in tanks of water, and the exact amount of water displaced was noted, part of a painstaking effort to determine the precise body density. The X-rays, the blood sampling, the needle punctures, were beyond counting. It went on for seven days. The result was a report in each of ten medical areas.

Those who reach final selection are mature men, most of them with 1,800 hours or more of jet-fighter training with the military. Yet as they make the initial move into the programme at the Manned Spacecraft Center in Houston, Texas, they appear to the men responsible for moulding them, "a bit like first-year college students, unsure of themselves—but they learn quickly!"

The learning is not haphazard; there

is a systematic programme of training and education. The general training lasts approximately 18 months. For three days each week during the first four months the candidate goes to school at 8 a.m. in the Manned Spacecraft Center. The first class lasts about two hours. There is another class before lunch, then a final class, from 2 to 4 p.m. During the two-hour break for lunch the candidate is expected to keep up with his fitness programme in the astronauts' gym.

There are ten courses offered, some of them background information concerning the overall space programme, others offered to familiarize the candidate with the various NASA projects and space flight operations. The basic courses are astronomy, physics of the upper atmosphere, flight mechanics, meteorology, rocket propulsion, the medical aspects of space flight, and, for those destined for lunar landing missions, the most extensive course, geology.

Two days of each week are given over to field trips that supplement the classroom instruction. The only breaks in this routine during the opening four months are the periods when the men are flying in order to keep up their jet proficiency status.

Geology is the one course that lasts longer than four months. It totals 112 classroom hours and may continue for eight months. Dr Ted H. Foss, head of the Geology and Geo-Chemistry section at the Manned Spacecraft Center, said, "There are two reasons why we spend so much time on geology for those astronauts who will be assigned to lunar landing missions. The first is that most of the people are encountering it for the first time—as a distinction from astronomy or flight mechanics, where the bulk of them, as experienced fliers, have detailed knowledge. The second reason



Next year: two men on the Moon

AND 50 lb of Moon samples back on Earth. That is the target set by US space planners if all goes well during the three test flights of the Apollo spaceship scheduled for the next few months. A circumlunar flight is planned before the final Moon-landing mission—which means that the first manned Apollo to leave Earth orbit is only four launches away. Crews for the fourth and fifth missions have not yet been picked, and the exact landing spot on the Moon is also still under discussion.

In Houston, Texas, the Lunar Receiving Laboratory of the Manned Spacecraft Center has begun limited operations to prepare for the receipt of the returning astronauts and their priceless samples. The three-storey Laboratory is full of scientific apparatus to analyse the 50 lb of material which the astronauts will be able to bring back. Elaborate quarantine facilities have been built into the structure.

After the Apollo spacecraft is taken aboard the prime recovery vessel in the Pacific Ocean, the three astronauts will transfer through airtight plastic tunnels into a mobile unit, which will be flown to Houston. Here, the astronauts will spend 30 days in quarantine whilst they, the spacecraft and the Moon samples undergo exhaustive examination for possible harmful organisms.

At the Laboratory, urgent scientific investigations will be performed on the lunar material. One of the prime aims is to determine if there is any life in the material that may reproduce. Until such tests are completed, the crew reception and sample operations areas will be isolated biologically so that there can be no possible cross-contamination between Moon and Earth materials.

After the quarantine period is over, the Moon specimens will be repackaged and distributed to selected scientists for detailed analysis. Researchers from the United States, Canada, Finland, Germany, Japan, Switzerland and the United Kingdom are to perform a total of 122 experiments to determine the properties and possible history of the lunar material brought back. Experimenters have been chosen with care to ensure maximum efficiency in the study of the precious fragments of Moon. It is expected that, on completion of their studies, scientists will know a great deal more about the evolutionary history of the solar system.

An overall view of the Manned Spacecraft Center at Houston, Texas



is that we want to give these men a sufficient background so that they can perform as field geologists on the lunar surface. We want them to be able to make judgments as to what to look for on the Moon, what to accept, what to reject, what samples to bring back that will have the most significance. They are not just going to take a walk out from the landed spacecraft—they are going to make meaningful excursions."

In addition to geology classroom work the lunar-mission astronauts go on ten field trips averaging three days each. The field trip sites are the Grand Canyon in Arizona, Big Bend National Park in Texas, Newberry Volcano in Oregon, Valley of 10,000 Smokes in Alaska, Valles Caldera in New Mexico, Pinacate Volcano in Mexico, the island of Hawaii, and Iceland. The field sites have been selected as offering the best examples of types of features that might be encountered on the Moon.

"Probably the first things astronauts will look for on the Moon," Foss continued, "are rocks that they have seen on Earth. If they find rocks that are of volcanic origin it may give an answer to some of the very fundamental questions about the history of the Moon—where it came from, how it was formed. Then they'll start a systematic job of sampling whatever rock material is available. They'll be able to bring back just 50 lb of samples. We would like them to pick up as much variety as they can get."

After the first four months, none of the instruction comes in neat packages. All of it is interwoven with a score of events that go on almost simultaneously. The demands on the time of the candidate astronauts is awesome. In addition to the geology field trips they journey to NASA's Michoud Facility in Louisiana, and to the Marshall Space Flight Center in Huntsville, Alabama, for launch-vehicle familiarization. They study the working of Mission Control at Houston as well as the details of recovery operations. They obtain Apollo command module and lunar excursion module familiarization at Houston, and they journey over to Kennedy Space Center

in Florida for launch operation familiarization.

There are visits to Wright-Patterson Air Force Base in Dayton, Ohio, where the candidate flies in a jet-plane that has been specially modified to provide an experience of weightlessness. Further journeys are required for training in desert, jungle, and water survival.

Training with simulators is the backbone of astronaut activity after he finishes formal classroom instruction. These simulators include the most sophisticated devices in the world. The astronaut gets a taste of three-axis control in a spacecraft mock-up known as a part-task trainer. It is here, in progressive stages, that an astronaut practises the manoeuvres of launch, retrofire, re-entry, and rendezvous. The part-task trainer is an immensely popular device, and an astronaut with a few hours to spare will ask for a "slot in the trainer if it is free". There is no requirement for a certain number of hours.

The docking trainer is a further step. In a cavernous room, dimly lighted, a spacecraft capsule moves forward, down and above an elusive docking target, both of them seemingly free-floating. The astronaut flies in, docks, then is reset at 15,000 feet and repeats the procedure. It's far more difficult to dock in the simulator than it is to dock in space.

When a new astronaut is assigned to a specific space mission, he begins an intensive period of training on the mission simulators. For a Gemini flight, this period lasted four months. For Apollo flights it lasts six months.

The mission simulators at Houston replace, by simulation, the launch vehicle, the spacecraft, the radar tracking sites, and, at times, the target vehicle. The big advance in simulators has been in the outgoing visual displays—the ability to look out the window and watch the world go by. They are so realistic that one can become seasick watching the floating continents. This is the final, large-as-life phase of training before the astronaut takes his first step into space and, very soon, on towards the Moon.



Astronauts experience weightlessness for about one minute and float around the padded cabin of a transport aeroplane. The aeroplane achieves this zero-gravity effect by diving steeply and then looping up and over in a high-speed arc

Astronauts John Young, Charles Conrad, Jim Lovell and Tom Stafford collect rock samples during geological training at Grand Canyon, Arizona. All four men feature among the backup crews named for the first three Apollo launches



"Thirty days hath. . ."
Can time-consuming
calculations like
this be prevented?

A World Calendar

by C W ALLEN,
Perren Professor
of Astronomy in the
University of London

SERIOUS calendar reform proposals have been put forward for over 40 years without getting much backing or interest from the public. The faults in the present calendar are readily acknowledged, but there is a wide impression that such faults are inevitable and that the improvements suggested are not worth the trouble. The calendar reformers have been willing to contend with the difficulties, but without avail so far.

The starting point for any calendar reform must necessarily be our present Gregorian calendar. It has been in use since 1752 (in England) and represents an accepted scheme for synchronizing events throughout the world. Its reform would require complete international agreement in the face of opposition from those who consider features of the present calendar to be essential to their institutions.

Before considering possible reforms it has to be recognized that the present calendar has some good points which should be retained if possible. The division of the year into 12 months is excellent for the regulating of all seasonal matters and there is no justification for changing the number of months in the year. The seven-day week suits well-entrenched, useful habits and there is no justification for changing to a shorter or longer week.

There are two major changes to be considered: (a) the monthly reform, i.e. the regularizing of the months so that they all contain 30 or 31 days, and (b) the weekly reform, i.e. the introduction of one or two eight-day weeks each year in order to create a perpetual calendar. The best solution for making these changes is that proposed by the World Calendar Association, whose calendar

THE WORLD CALENDAR						
January, April, July, October						
Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.
1	2	3	4	5	6	7
8	9	10	11	12	13	14
15	16	17	18	19	20	21
22	23	24	25	26	27	28
29	30	31				
February, May, August, November						
Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.
			1	2	3	4
5	6	7	8	9	10	11
12	13	14	15	16	17	18
19	20	21	22	23	24	25
26	27	28	29	30		
March, June, September, December						
Sun.	Mon.	Tues.	Wed.	Thur.	Fri.	Sat.
					1	2
3	4	5	6	7	8	9
10	11	12	13	14	15	16
17	18	19	20	21	22	23
24	25	26	27	28	29	30 (31)

June 31 = Leap-Year Day (Saturday). Only leap years.
Dec. 31 = Year-End Day (Saturday). Every year.
There is no March 31 nor September 31.

(slightly modified) is shown here.

The following features of the world calendar can readily be seen. It is perpetual or fixed, so that every date will fall on the same day of the week. For example, December 25 will always be Monday. The proposed changes from our present calendar are small and could cause very little inconvenience. The year is divided into regular quarters with 91 or 92 days in each. The intercalary days, as June 31 and December 31 are

often called, would be holidays, so that each quarter would be exactly alike if these days were omitted. (However, there is a danger in allowing any day to be completely detached from its month or week. There must be a place for every day in the appropriate monthly or weekly tabulation.) Each quarter contains only complete weeks, which would make for great convenience in relating weekly to monthly accounting. The monthly pattern of 31 30 30, 31 30 (30), 31 30 30, 31 30 31 days is as regular as it is possible to make it. Not only are the quarters regular but in leap years each pair of months contains 61 days. All months contain 26 weekdays.

The world calendar has been presented to public bodies, to governments, and to international bodies at every opportunity since about 1930. The highest hopes of its adoption came in July 1954 when the United Nations Economic and Social Council requested that the world calendar be presented to state members and to non-members of the United Nations. These were asked to study the problem and furnish their views by early 1955. By the May 1955 session only 30 governments had replied and the item was postponed. Any hope of agreement later was

apparently wrecked by a brief letter from the United States State Department to the General Secretary of the United Nations saying that the United States Government opposed any change in the present calendar, and that further study served no useful purpose. Without doubt this letter had great influence, and the April 1956 session of the Economic and Social Council adopted a Netherlands proposal to postpone world calendar reform indefinitely.

In the decade since 1956 the world has continued to reform, regularize and standardize its units but has left the calendar alone. There is no concerted effort to correct the month lengths which vary from 28 to 31 days, nor to tie down important annual events which at present are forced to jump as much as six days from one year to the next. The reformer might well say: Is not the calendar on which we all plan our lives deserving of as much consideration as the mile, the ton, or the shilling? Are we not entitled to use our months and weeks for precise regular statements which can be compared from one year to the next? We may be used to this Gregorian calendar and may have learnt to put up with it, but we claim we are entitled to the best arrangement our 365 2422 days a year will provide.

Weekly reform

One difficulty with calendar reform is that it affects everyone but is the concern of no one in particular. There are plenty of collaborating economists, statisticians, engineers, educationists and scientists to set up international commissions for the standardization of everything else, but not the calendar. An attitude expressed in America in 1956 was that "the United Nations should be able to find better things to do than tinker with the calendar", and the attitude in Britain appears to have been similar. However, calendar reform is the type of universal problem that particularly needs the consideration of the United Nations.

The real crux of the calendar reform failure rests on what I have called its weekly reform. This provides both the greatest advantage, through the introduction of a fixed calendar, and the greatest opposition, because of the break in the seven-day weekly sequence. It would be a mistake to make the monthly reform without introducing the weekly reform at the same time. But the weekly reform is opposed on religious grounds—hence the impasse.

There is very little chance of introducing calen-

dar reform until religious opinion becomes more liberal. Fortunately there are heartening moves in this direction, and perhaps we will enter an era when the calendar problem can be considered again. In October 1963 the Vatican Council approved the fixation of Easter and mentioned Sunday, April 8, as the proposed date for Easter Sunday. It is evident that the Vatican has the fixed world calendar in mind. However, the opposition to the world calendar has come mainly from sects with rigid sabbatarian interests—the Jews and the Seventh-day Adventists, for example. It is not too much to hope that these may become more liberal and withdraw their obstruction to a movement that concerns everyone else.

Double dating

Many people agree that a change to the world calendar is well worth while. There will be some opposition for varied personal reasons. For instance, some will object because they do not like the weekday on which their birthday falls.

But what we all need is a scheme which will enable us to plan future events without double dating and other misunderstandings. Many of these costly errors could be eliminated if it were possible to picture the calendar well into the future and place the main regular events solidly into place. The sporadic events would then fit into a clear predictable timetable.

Calendar reformers need the support of those organizations that would benefit from calendar improvement. The monthly reform is needed by statisticians, meteorologists, geophysicists, economists, accountants and others who use monthly data for precise purposes. The weekly reform is required by everyone who has to plan time schedules for a year or two into the future. Schools and colleges are particularly concerned. With the present calendar there is an extra week that appears every few years and has to be forced into a term or a vacation. Every authority decides arbitrarily for itself where to fit this jumping week, with resulting lack of coordination. These difficulties would disappear with a fixed calendar.

Calendar reform needs new momentum from someone in contact with the reins of government. It will have to reappear on the agenda of a United Nations council before it can be adopted, and its chance of success will depend on the public backing it receives.

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Our Galaxy

Recent trends in cosmology threaten to throw theories about galactic evolution back in the melting pot. CLIVE HALE reviews classical ideas on the history of a typical galaxy—our own

IT WILL appear obvious to anyone who merely glances up at the sky that the stars are not placed at random. Herschel studied this almost 200 years ago and he concluded that the galaxy was a lens-shaped object with our solar system in the outskirts. He could go no further as there were no measures of stellar distances until well after he died. In 1836 stellar parallax was discovered, but this did not greatly advance the description of our galaxy because the method used could not find the distance of stars other than those very close to our Sun.

This method—the parallax method—uses the Earth's motion to measure the apparent angular movement of a nearby star against a background of far more remote stars. If that star's parallax is found to be one second of arc, its distance can be termed one parsec. A parsec is equal to approximately $3\frac{1}{3}$ light years, although no star has yet been found as close to us as that. Parallaxes are not reliable when they become as small as 0.05 seconds of arc and absolutely useless if smaller than 0.02 seconds of arc. Therefore, they can only be used to find distances not more than 50 parsecs or 160 light years at the most. Matched against the distance of our Sun from the centre of the galaxy, 10,000 parsecs, then this 50 parsecs limit seems minute.

To make further progress in forming a correct description of our galaxy use was made of the observed brightness of stars—apparent magnitudes. It was argued that if light from a star was not partially absorbed on its journey to us the intensity of the light received would be proportional to the inverse square of the distance of the star from the solar system. This method would work admirably, apart from absorption, if the stars were all of the same intrinsic brightness (absolute magnitude), but they are not. Stellar intrinsic brightness varies by more than 10,000 to 1 from the brightest to the faintest stars. Therefore, a way of determining absolute magnitudes had to be found before this method could be used.

At the beginning of this century a way was found. It was noted that the intrinsic variables showed a clear relationship between absolute

magnitude and period of pulsation. It was also found that stellar spectra give indications of a star's absolute magnitude, so we could have mapped the galaxy in the 1920s, but for the obscuration which blots most areas around the centre of our galaxy. In 1930 the distance to the centre of the galaxy was regarded as quite uncertain by Eddington and most astronomers. Shapley, however, gave a value by using a method which does not have to be altered much today.

Shapley started by observing the globular clusters; there are about 80 of these clusters known. Each contains a large number of stars, about 100,000 or so. The structure and equilibrium of these objects present difficult but interesting problems. Their importance as far as the size of the galaxy is concerned is that Shapley could determine their distance from the Sun. This he could do in three ways; firstly, about one-third of the globular clusters had variable stars in them, enabling him to determine directly the distance of the cluster from the solar system, if there was no absorption and if the intrinsic intensity of the variable was known. If a cluster did not contain any variables Shapley assumed that the intrinsic luminosity for the brighter stars in all clusters was the same, and used this fact to find the distances of those clusters with no variables by comparison with the known distances of variable-rich clusters. Lastly, some clusters are too far off to be seen as individual stars. For these clusters Shapley assumed that all globulars have the same diameters, reasoning that if a cluster of unknown distance appeared one-fifth of the size of one of known distance then it would be five times as far away as the latter. In this way Shapley found the distances of globular clusters known to him and argued that they were symmetrically distributed around our galaxy with the centre of the system at the centre of the galaxy itself.

The above method works because globulars are observed away from the plane of the galaxy where the heavy obscuration lies, and so clusters may be seen right across to the other side of the galaxy. Shapley estimated the centre of the

galaxy to be about 16,000 parsecs away, but this figure has now been modified to about 10,000 parsecs because of revised corrections for absorption effects and modifications to Shapley's figure for the intrinsic intensity of the variables.

We have deduced the size of our galaxy, but from size alone we know nothing about the galaxy's mechanism. We have to observe motions of nearby stars and this can be done in two ways. Firstly, from doppler shifts in their spectra we can deduce their radial velocities, and, secondly, transverse motions (at right angles to radial motions) can be found by comparing their change in position on photographs taken many years apart.

If the galaxy rotated as a whole like a solid wheel, galactic rotation could not be established by observing the motion which two parts make relative to each other. Other spiral galaxies look very much as if they rotate differentially, so we look to see whether or not we are being overtaken by stars inside ourselves, and it is evident that this is the case. We know from this that the centre of the galaxy is 10,000 parsecs away from the Sun. Also we can deduce that the circular velocity in our zone is approximately 250 km/sec, and that it takes us 2×10^8 years to go right around the galaxy.

The galaxy contains a vast number of interacting stars. Stars are spaced so far apart that they little interfere with each other, even in 10^{10} years, the time we think the galaxy has existed. So stars which start with near circular orbits continue to have near circular orbits even if they travel around the galaxy 200 times. Stars, however, are formed from gas. In our galaxy there is still plenty of gas not formed into stars. The presence of this was first noted in stellar spectra (interstellar lines) and is charted at 21 cm wavelength by radio astronomers (see *The Radio Galaxy* by Professor R. Hanbury-Brown in *Hermes*, April 1968). In this gas the particles cannot move about independently of each other. Gas is very sticky. If two gas clouds meet they would join together and share a common motion. The only method by which all gas clouds move around the galaxy without colliding with each other is for them to move in circular orbits in the plane of the galaxy.

So, if a star is to be formed nowadays, it must be formed out of today's gas which moves in circular orbits and stays close to the galactic disc. It then follows that the recently formed star moves with the velocity of the gas from

which it condensed, has a near-circular orbit and stays close to the galactic disc. This implies that disc stars are new stars, while halo stars are old stars which were formed before the galactic gas had time to order its motion.

This argument is well supported by stellar spectra. It can be supposed that the original gas in the galaxy was hydrogen, and that more complex elements are built up by nuclear processes which only occur at the centre of stars. The gas which we observe nowadays has a high metal contamination rate and indeed the first interstellar lines to be observed were lines of calcium. Some stars suddenly burst out into novae or supernovae, and by these processes and by more violent ones perhaps, the heavier elements are spewed up from the interior of stars to be scattered around interstellar space.

Therefore, the old stars might have been formed out of pure hydrogen and the newer stars out of a contaminated mixture. The question is whether this should show up in stellar spectra. Now, if the old stars had formed their own metals in their interiors and then transferred these metals to their surfaces, there would be no obvious difference. However, it is probable that there is a good deal of stratification in the interiors of stars so that these metals (if they were produced) would find it hard to reach the surface. We therefore suppose that old stars have spectra not showing much metal while new stars have spectra rich with metal. To find the metal content in a star's spectra, elaborate analysis is called for. These analyses are currently being performed and they do support the argument of the division of old and new stars.

All stars can pulsate but this does not mean that they will do so. Take for instance a piano—a string is tuned to a certain note, but it does not sound unless it is struck. If it is struck the sound dies away quickly because in making the sound the string has worked against the surrounding air and in the course of time the energy given to the string by striking it is dissipated and the note dies. To make a continuous note it is necessary to keep on applying energy to air vibration, as continually bowing a violin string or in some electronic device where energy is continually fed into an oscillator. Now many cepheid variables have been observed pulsating for about 50 years (5,000 cycles) without any observed diminution, so that damping must be very small indeed on the energy being fed into the oscillation. Stars which do not pulsate are damped like a piano

wire, and stars which do pulsate have some method of keeping energy being fed to a pulsation.

The typical cepheid variable with a period of more than one day is inclined to hug the galactic plane and have a near circular velocity. So we see that they are new stars experiencing an early pulsation period. The short period variables, however, are old stars which would have been formed early in the history of our galaxy when gas was not in circular motion. These are known as RR Lyrae stars and they still describe the same orbits as they did when they were formed. They, therefore, move in highly elliptical orbits usually steeply inclined to the galactic plane and appear to be moving fast compared with us.

Sandage, Eggen and Lynden-Bell recently put forward a detailed theory for the formation of the galaxy. They propose that the much larger gaseous body collapsed in accordance with Newton's theory of gravitation. The outer parts of this system would fall into the centre in mainly radial directions, that is falling from all points toward the centre. However, something "went wrong" and the centering was not perfect, so discrepancies must have occurred. We know the galaxy must have the same angular momentum

as it did in its expanded state. We can, however, suppose that the gas clouds fell into highly elliptical orbits, and were not distributed quite at random, but held a preference for the direction of the present galactic rotation. At this stage the gas clouds were capable of condensing into large star clusters, since the globular clusters are very old and are high velocity halo objects. There are also individual stars with the same motions and these were also formed in these early stages either individually or from clusters which broke up subsequently. There are also some stars and clusters with intermediate kinetic properties. They do not have circular orbits, but they are not highly elliptical either. They do not hug the galactic plane, neither are they very far away from it. These clusters were formed when the gas had settled down somewhat, but not totally. It is also possible if not probable that serious explosions took place after the original collapse starting up fresh radial motions. The development of this theory, together with the development of the theory concerning stellar evolution by studying the actual nuclear processes in stellar interiors, represents the major advance in optical astronomy which has taken place post-war, and the two are linked closely in many ways.

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Greenwich Observatory 50 Years Ago

Prof SYDNEY CHAPMAN, FRS, was born in Lancashire 80 years ago. Today, working in Boulder, Colorado, he remains an active geophysicist after half a century at the top of that field. After taking a degree in mathematics at Cambridge, Chapman served at the Royal Greenwich Observatory between 1910 and 1914. Here he describes how he became involved with astronomy, and reminisces on life at Greenwich

EARLY in my third year at Cambridge, on a Sunday, I had gone out for a long walk in the country, as was my habit. Rain had come on, and returning to my room I unlocked the door and walked in; there I found a man sitting on my sofa. His first words were, "I'm the Astronomer Royal". It was Dr Frank Dyson, who later became Sir Frank Dyson. He came to interview me in connection with a job at Greenwich Observatory, and a few days later he definitely offered it to me.

In those days, and indeed now, there were few jobs for astronomers in England. The tendency would be for the top people in the examinations in mathematics and physics not to go in for astronomy, because if they started at the bottom they might have to wait decades before one of the better jobs fell vacant. So at Greenwich Observatory the practice had been adopted of filling the two posts next to the top (called chief assistants of the Astronomer Royal—in effect they were assistant directors of the Observatory) by well-qualified mathematicians straight from the university. This was how Eddington was appointed in his twenties. I was offered a post likewise—I was then 22. My pay was £500, enough to keep a big house and have a couple of servants and raise a family of several children.

Magnetic observatory

I had never thought of becoming an astronomer and knew very little about it. I heard that the staff below this level, many of them very good people, had been trying to get this post abolished, to have only one chief assistant instead of two, and to have the pay divided between them. But this effort didn't come off. When I went and took the job, people after all were very nice to me, and very

kind when I made mistakes—I was a poor observer, and very inexperienced.

A magnetic observatory at Greenwich had been started about 1840 by Airy. He was Astronomer Royal for over forty years, and died when I was four. This magnetic observatory had become out of date. At first it had been above ground, and there had been a considerable daily and annual temperature variation, for which the records had to be corrected. Then it had been moved down into a basement, where the temperature variation was less, but was still rather a bother. So Dyson thought there should be a new one, and he gave me the job of seeing to it. I knew even less about the Earth's magnetism than I did about astronomy at the time, and had a lot to learn.

Lunar observations

Already at that time the magnetic observatory was disturbed by stray electric currents from electric railways some way off. From the beginning, when Charles II founded the Observatory in 1660, the Observatory had been under the British Admiralty because the original object of the Observatory was to find the longitude at sea, and it was thought that lunar observations would do this. It was still under the Admiralty, and the Admiralty was a powerful ministry, and through it the railways were made to alter their electric transmission lines in this neighbourhood to keep the Observatory from being disturbed.

So a new observatory was built, properly temperature insulated, and with modern equipment. Having had this task of making the magnetic observatory able to get better data, I began also to consider the results.

Far back in the early days of Greenwich Observatory, the first Astronomer Royal was a clergy-

man—most scientists in England in those days were clergymen. To continue to be a lifelong fellow of a college you had to be a clergyman and celibate. These rules were only relaxed about 1880. This first Astronomer Royal, Flamsteed, was paid £100 a year, but of course the value of money was quite different. He was made head of the Observatory to study the Moon and find a way of getting longitude at sea. He was expected to provide his own instruments out of his pay. Later Newton began to develop his theory of gravitation, which later he described in his *Principia Mathematica*, under Halley's persuasion, and they wanted some of the Astronomer Royal's observations to test the theory by. Flamsteed didn't want to give them up just when they wanted to have them. He thought they were his own property, because the instruments had been paid for by him. So there was a quarrel, and Newton's great influence got the Admiralty to form a Board of Visitors to the Observatory, which went each year and inspected what was going on, and told the Astronomer Royal what to do if he wasn't doing it. This body has survived until recently.

Monthly magazine

The Astronomer Royal before Dyson, Airy's successor, Christie, started a monthly magazine issued from the Observatory; its title was simply *The Observatory*. Begun in 1877, it continues to this day, and one valued feature of it is its reports of the discussions on the papers presented at the eight meetings of the Royal Astronomical Society each year. When I joined the Greenwich staff, the editors were two astronomers there, Lewis and Hollis, who were proprietors of the magazine. They had had to put some small sum of money into it on taking it over from the earlier editors. Besides Christie, these had included Maunder, a man greatly gifted in the graphical representation of data; his most famous example was his butterfly diagram, which shows the succession throughout the sunspot cycle of spots and their latitudes on the Sun.

Lewis and Hollis were getting old and wished to retire, and Eddington, Stratton and I agreed to take it over. Each of us paid £20 to acquire the property and the burden of editorship.

When the time came for us to give up our editorship—I was the first to withdraw—our successors paid the same sum to us. We never drew anything from the magazine. In the 35 years before we took over, there had been five editors.

Since that time the editors have changed every few years. I think I was one of the most transient, and I set the fashion for being editor for only a short time. There have been 36 in the 56 years since 1912. The editors take it in turn to be reporter at the Royal Astronomical Society meetings.

The subscriptions to this little magazine just about paid for the cost of the printing and postage in our time. Later on when costs increased, the then editors asked the RAS from time to time for a subsidy and thus they kept the magazine going. The Society was glad to have this journal reporting the discussions at its meetings, which were often very interesting. Many years later, when I was president of the Society, I conceived the idea of the Society not giving a subsidy, but instead paying a block subscription, in return for which every Fellow would receive a copy. Of course, this meant that the editors would have to give up the subscriptions paid till then by a number of Fellows, but a scheme satisfactory to all was worked out and continues to this day. The magazine remained the property of the editors, but its circulation was very much increased.

My stay as chief assistant at Greenwich Observatory was short—only four years to 1914. In the middle of this period, Eddington was elected professor of astronomy at Cambridge and re-elected Fellow of Trinity College. There he spent the rest of his life. I was elected a research fellow of the college a year later, in 1913, but I could hold it without leaving Greenwich. I became the senior chief assistant, and Harold Spencer Jones took my place as junior chief assistant. Later he succeeded Dyson as Astronomer Royal and became Sir Harold.

Knighthood prospect

If my whole heart had been in the Observatory and its work, it might have been expected that after about twenty years I should succeed Sir Frank Dyson and become Astronomer Royal and later be knighted. But though I liked the Observatory, and was immensely grateful to the Astronomer Royal, and though I became much interested in astronomy, I did not relish the prospect of directing an institution, nor of devoting myself predominantly to astronomy. Nor did the prospect of a knighthood tempt me to deviate from my inclinations. Dyson and Eddington tactfully sought to turn my thoughts and efforts more exclusively to astronomy, but the job of designing a new magnetic observatory turned my mind to

geomagnetism, and this has enthralled me ever since.

I was assigned a share in the observing programme of the Observatory, with the transit circle, and with a reflector for stellar photography, and with a refracting telescope to observe double stars. I was not a good observer. Another task that I took over from Eddington was examining bright grade school boys who sought employment in the lower ranks of the Observatory staff. This had been the practice for decades and had worked well. The better ones continued their education at evening school, and one or two grew into really good astronomers; at least one of them became a Fellow of the Royal Society. Nowadays, of course, entrants to the Observatory have been to university and got degrees.

The main piece of astronomical work I was given to supervise was the counting of stars down to successive limits of magnitude or faintness on a remarkable set of large 15-inch-square glass plates that together covered the whole sky, north and south of the equator. They were provided by John Franklin-Adams, a member of the famous old London underwriting corporation, Lloyd's. He became very wealthy, and having been fasci-

nated with astronomy from his youth, set up an observatory in more than one place where he lived. He conceived the idea of making an atlas of the Milky Way, and commissioned the construction of suitable telescopes by the best makers for the purpose. Later his objective grew to cover the whole sky.

He went to the Cape of Good Hope Observatory to photograph personally the part of the heavens only visible from the Southern Hemisphere. The plates then taken were, however, found not to be good enough, and the series was completed with his instrument by professional astronomers at the Cape. After I had begun my work on the plates, Dyson once took me to see him. By that time his state was pitiful—he had lost much of his wealth and was very ill and bedridden. A pathetic part of our interview was an indirect appeal he made to the Astronomer Royal that he gain him recognition for his scientific astronomical work by election to the Royal Society. Dyson was necessarily very reserved in his reply, knowing that such an event was scarcely possible. I visited the poor man from time to time after that; he died about a year later, and soon afterwards I left my post at Greenwich.

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The Moon comes down to earth at the Geological Museum

IT'S QUITE A SIGN of the times that the Geological Museum should be devoting many square feet of space to a permanent Moon exhibit. The remarkable thing is that no one anywhere else has got around to putting on such a full-scale display. Rumour has it that requests for the exhibit's loan have already come from America—and it's American space-probe information which makes up the greatest part of our recent lunar knowledge.

"We're going to keep the exhibit up to date as lunar exploration advances; we hope eventually to have on display one of the first pieces of real Moon brought back by astronauts," says Dr Peter Adams, the Geological Museum officer in charge of the exhibit. "It seemed a very obvious thing to have a lunar display here. The Americans and Russians are gathering great amounts of informa-

Sir G Sutton, Chairman, National Environmental Research Council, and Dr P J Adams, in charge of the Moon exhibit, examine the model Surveyor spacecraft on display at the Geological Museum



tion in which we, as geologists, are interested. There's so much available now."

Dr Adams' expansive exhibit traces the development of lunar exploration from the early Luniks and Rangers to the sophisticated soft landers and orbiters of today. Display panels show that it is now possible to draw phenomenally detailed maps of the lunar surface and make accurate deductions about lunar surface-moulding history by study of Moon-probe photos. Astronomers and geologists alike have been astounded at the wealth of detailed information scientists have gleaned from pictures of the Moon's surface. Most of the material on show has previously been available only to professional researchers.

To go with the exhibition, Dr Adams has written a booklet summarizing current opinion on the Moon's origin and history. "I don't regard myself as an expert," Dr Adams tells me. "It was a case of assessing the literature to produce a fair picture of present knowledge." Quite certainly the result—like the exhibition—is an excellent example of objective science, and it's probably true to say that the views expressed at the Geological Museum are the definitive ones. At least, for the moment.

They're making good use of neglected instruments

"FOR A LONG TIME we've felt the need for a local astronomical society, and already we think it's justified its existence." Paul Sutherland and John Watler are both not quite sixteen years old yet they've set themselves up as secretary and chairman respectively of the Thanet Astronomical Society for Youth. The society held its first meeting in May, and has proved a roaring success.

They've been helped by Mr Samuel Mitchell, a nearby member of the RAS, who says, "My interest in astronomy goes back to the days before World War I, when as a very young choirboy at Greenwich Parish Church I used to see each Sunday Sir Frank Dyson and his family in the Royal pew."

Mr Mitchell moved to Yorkshire and joined the Leeds Astronomical Society, becoming its President in 1951. He remembers giving talks to the now defunct Leeds group of the JAS just after its formation ten years ago. Help of the same kind to start this new Kentish society has come from Mr Mitchell, who adds, "I have every admiration for young people taking the initiative in forming their own groups to satisfy local need." Now an astronomy lecturer in the Extra Mural Departments of London and Oxford Universities, Mr Mitchell is the Thanet society's patron.

Motive force behind the society's formation is Paul Sutherland, who advertised extensively to make a success of the first meeting at Hilderstone, the local education centre in Broadstairs. "To our surprise," says chairman John Watler, "28 people turned up and we discovered quite a few keen astronomers previously unknown to us."

So far, the Thanet Astronomical Society has held four meetings and two meteor watches. "Although we shall continue to have meetings and film shows," says secretary Paul Sutherland, "our main aim is to become an active society doing as much practical work as possible."

Paul is very keen that the society should affiliate to the JAS, and he's considering the publication of a newsletter to carry the large amount of observations expected. "We've been pleased to find that the majority of our members own useful instruments, although several of these have been left unused for too long," he says. "Our job now is to go round and dig these out."

Soviet spacecraft on show for the first time in Britain

THIS TIME OF THE YEAR is exhibition season the world over. Weighing in with what must have been the largest of them all, the Russians sailed up the Thames in a cloud of spray with Kometa, their large hydrofoil. It amazed the Thames rivermen if no one else, although the actual purpose of the voyage was to open the Soviet Trade Exhibition at Earl's Court.

In the exhibition itself it was difficult to escape from those amazing shiny spacecraft replicas dangling from the ceiling. In fact, the interior of the Earl's Court arena was built up to make the space section as obvious as possible. All the other exhibits—such as nuclear power, furs, or the artificial forest with recorded birdsong—were arranged petal-like at the edges of a large pool



A moment of peace in the chaos of preparations. This Russian engineer takes time off for a pipe dream of the Moon as he sits behind a replica of Luna 9, the first soft-landing lunar spacecraft

of water, over which stretched the red-carpeted avenue of space exploration.

The sight of five Soviet Moon probes together is awe-inspiring. Lunik II, Lunik III, Luna 9, Luna 10 and Zond III were all there—or, at least, their replicas, for not even the Russians have got as far as recovering their own Moon probes yet. The Molniya communications satellite is an enormous and leggy thing; Elektron 2, the radiation satellite, is surprisingly different from Elektron 1; Venus 3 and Zond III look almost identical; and a Cosmos meteorological satellite that looks like a beer barrel with wings dwarfs completely the tiny spider of Sputnik 1. A Vostok upper stage is there, and should be on a stand but it fell off. (The round mark at the bottom of the water tank shows where it got to.) Nearby is Gagarin's actual capsule, which has the scorch marks of re-entry heat carefully touched in for each new public showing—people will keep fingering it, and most of the real blackness wore off years ago anyway.

The exhibition's theme was 'Through trade to peace and mutual understanding,' and reciprocated the British Industrial and Trade Exhibition held in Moscow in 1966. Actually, the day I went—the day before the opening—it didn't look much like anything. In the end the turves must have got laid and the place swept clean and the impromptu boat-race crew saved from a watery grave in the decorative pool, although it seems that on opening day the labelling problem hadn't been solved completely. However, the Prime Minister enjoyed it; and the six Russian models gave regular fashion shows, three times a day, between August 6 and 24.

Shh! That secret scientist is at work again. . .

REGULAR READERS OF SPECTRUM will remember our recent visit to Mr T. B. Orton, inventor of the Ortoscope, reported in the April issue. We have just unearthed from the mails this letter, from the Ortona Ray Bio-Cybernetic Research Unit, dated August 6, addressed to the Astronomer Royal at Greenwich, London (where he hasn't been since 1957).

"Dear Sir, The Ortoscope is an instrument for detecting small but determinable quantities of high-frequency electrical energy. On the basis that all matter radiates, radiations from ordinary photographs can be detected by the Ortoscope.

"It has been ascertained that from a photograph of Polaris supplied by the Royal Greenwich Observatory (your letter reference no. 1901, dated 29-12-68) that this star contains only alpha particles, and that the celestial North Pole contains only gamma-ray particles, thus proving that the whole of the universe commenced originally at the celestial North Pole, and that the 'big bang' theory is untenable.

"I have further ascertained by Ortoscope the following:

- (1) That there is a total of 184 elements in the Earth.
- (2) That from the photograph of the Moon supplied from the Royal Greenwich Observatory, the number of elements therein is 182, thus proving that the Moon could not have been thrown off, or have been part of the Earth at any time, but was ejected by the Sun during a prominence or sunspot flare-up, in the same way as all the Sun's planets originated, but in different periods of time. This would appear to confirm Hoerbiger's cosmic-ice theory in respect of the Moon.
- (3) That the Sun contains *only* hydrogen.
- (4) That the terrestrial atmosphere surrounding the Sun and Moon contains only helium.
- (5) That the Earth radiates de Broglie waves, or compound wave forms of all the 184 elements contained in the Earth, as well as individual waves of each element. These de Broglie waves radiate out from the Earth to the Van Allen belt, where they meet the gamma and alpha particles from the solar system, where considerable heat is generated.
- (6) That Halley's Comet contains 157 elements, and is therefore a planet in formation.
- (7) That gravitation and/or magnetism is possibly caused by the interaction of gamma and alpha particles, by the 'Push-Pull' method. (QED.)

"In the meantime, arrangements are being made to publish these recent discoveries. I shall, therefore, be glad if you will kindly register these discoveries for prior claim."

Copies have also been sent to the Royal Society, the Nobel Institute and Imperial College, although Spectrum, never one to refuse a new chap a platform, was mysteriously left out of this glowing list. But, come to think of it, we weren't on the mailing list for the Astronomer Royal's reply, either.

Fighting the enemy from padded deckchairs

DOWN IN PORTSMOUTH, the home of the naval dockyard, there's quite a war going on—the tussle between telescopes and artificial lighting. "We've only been in the civil war business since October 1966, but sporadic firing has taken place from as far back as 1958," says M. J. Collins, Portsmouth Astronomical Society's public relations officer, who obviously takes it all very seriously. "Our membership is small in relation to other district societies," he points out, "but we are all observing members and this has enabled us to retain a high standard of work."

The idea of forming a society was put forward by P. R. Seiden, the present Chairman, who with friends started holding regular school meetings. They became junior members of the Portsmouth Astronomical Group until 1964, when they broke away to form a separate society. "It was really in our own interest that we break fresh," explains Collins, "because our standard of work and recording was much higher. Since then, we have quadrupled our membership and our observing quality is even better." The experience of being on their own, they say, has helped them to produce a society journal, *Quasar*, although Collins thinks that this might be a little premature.

The society's main interest is in meteors, and they're extremely proud of their luxurious padded deckchairs, each with a telephone link to a tape recorder. Among other observing projects they number Messier object recognition, minor planet and comet sweeping, and stellar spectroscopy. But what about all that artificial lighting? Say the Portsmouth Astronomical Society members, "We have never seen the reason why sophisticated astronomical work cannot be performed by amateurs from city skies. Make war on those sodium and mercury lamps!"

Comet Tails

Although comets are among the smallest objects in the solar system, their tails can extend for millions of miles. Changing tails are a great fascination, says KEITH HINDLEY

PERHAPS thirty comets every century become bright enough to be seen readily with the naked eye, and then usually for just a few days each; only a handful merit the word "great". The last half-century has been a particularly sparse period for really bright comets. Comets Arend-Roland 1957 III, Mrkos 1957 V, and Seki-Lines 1962 III were all remarkable, but in these recent years, only Comet Ikeya-Seki 1965 VIII has merited the prefix "great". Due to adverse weather, and the high latitude of the British Isles,

this comet was never well placed for observation from home. The last comet to be really favourably placed for British observers was Comet Seki-Lines 1962 III, shown in Fig 1. These illustrations show how impressive a well-placed bright comet is.

The naked-eye view on April 8 shows a comet head of about magnitude 2, with a beautiful 18° long curved tail—the 'scimitar' shaped tail frequently described in ancient reports of bright comets. Two nights later, when the comet had

Fig 1(a) Comet Seki-Lines 1962 III on 8 April 1962. With the comet at magnitude 1.8, this illustration was drawn by Keith Hindley from observations with the naked eye and binoculars

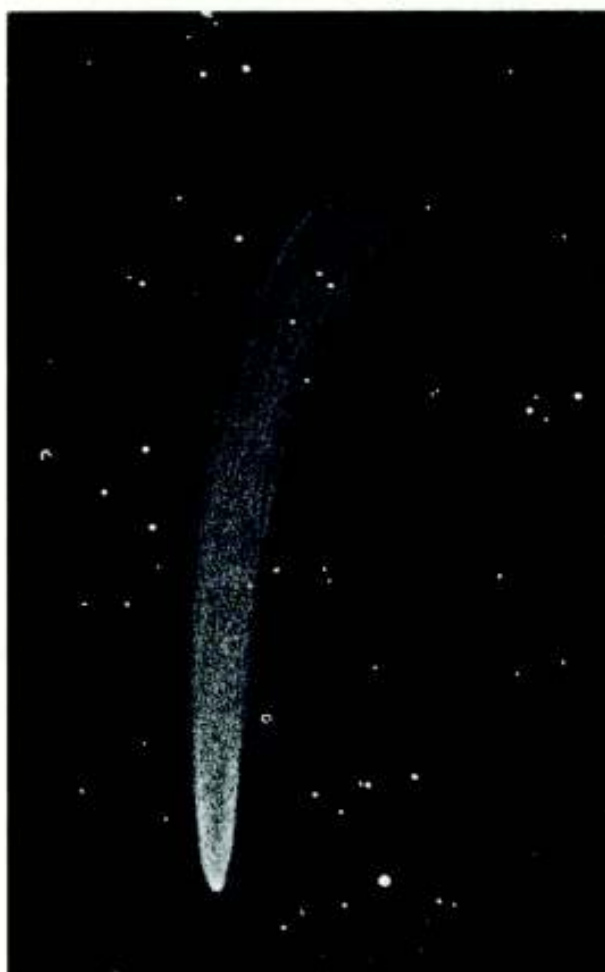


Fig 1(b) Comet Seki-Lines 1962 III on 10 April 1962. Here, the comet has faded to magnitude 2.5. For this photograph, Alan McClure used an f3.8 10-inch focus lens and a 10 minute exposure



faded about a magnitude, Alan McClure's photograph shows the tail less curved, but reveals a remarkable amount of detail, including aurora-like draperies in the tail. This clearly demonstrates the superiority of a good camera over the naked eye for recording diffuse tail detail.

To the naked eye all tails appear as diffuse streaks, with shape being the only really distinguishing feature. This shape has little to do with the actual comet head—it is a result of the shape of the comet's orbit, coupled with perspective effects as viewed from Earth. Observation has shown that material from the head of a comet moves down the tail—away from the Sun. Light pressure and the solar wind are thought to be responsible here—the vast amount of light and radiation emitted by the Sun repels glowing gas and dust particles from the comet head.

If the comet were stationary, the tail would point exactly away from the Sun along the radius vector. Comets are, in fact, moving along their orbits, meaning that the tail always lags behind the radius vector to a larger or smaller degree depending not only on the speed of the comet, but also the sort of material in the tail. Luminous gas accelerates away from the head at high velocities, producing fairly straight tails close to the radius vector. Tiny dust particles are accelerated only slowly, lagging a long way behind the radius vector, and producing curved tails. It is possible for a comet to show two tails, one a gas tail and the other due to dust—indeed, Comet Mrkos 1957 V showed these two types very well. On rarer occasions, when different types of gas and dust are present, comets can show more than two tails. The Great Comet of 1744, for example, showed at least six tails.

The curvature of comet tails is only seen if we view the comet near, or at right angles to, the plane of its orbit. If we view the comet in the plane of its orbit, perspective makes the tail look straight.

The source of all this tail material lies in the comet head or coma. This usually has dimensions of planetary size, but the only substantial piece of material is the central nucleus. Just what the nucleus consists of is a matter of opinion. It is probably a compact fairly solid body several miles across, made up of frozen gases, dust and chips of stony and metallic material—literally a 'dirty snowball'. Although this is probably correct, some authorities prefer a loose cloud of ice-flakes and solid chips. The distinction is not important for the purposes of this article.

Whilst naked-eye observations of comet tails are of limited value, visual observations of comet heads using a good telescope can record detail almost impossible to photograph. Comet heads and the tails in the region of the head show a remarkable variety of shapes, such that it is probably true to say that no two comets are alike. Despite this uniqueness, one can draw up general rules on how comet tails develop as the comet approaches the Sun.

Imagine a comet of the type described above approaching the Sun from the depths of space. It looks like a faint circular patch of mist, slightly brighter in the centre where the nucleus is. The comet is still cold and inactive, but by the time the comet reaches the orbit of Jupiter, the increasing amount of light and heat it has received causes the central part of the coma to brighten as ices evaporate from the nucleus. The coma begins to shrink as it brightens due to the stronger light pressure and solar wind stripping off the tenuous outer layers. Soon material from the nucleus starts to stream away from the head to form a fine thin tail like Fig 2a. Here Comet Honda

Fig 2(a) left: Comet Honda 1962 IV, magnitude 7-8, drawn on 4 May 1962. Fig 2(b) right: Comet Ikeya 1963 I, magnitude 3-4, drawn on 18 March 1963. Drawings shown here are by the author



1962 IV, is shown just inside the Earth's orbit. This comet, like Comet Burnham on this month's cover, was never closer than 60 million miles from the Sun and so did not develop a more complex tail. Comet Ikeya 1963 I (Fig 2b) approached a little closer, its fine thin streamers widening to a broad cluster of diverging streamers.

A comet that approaches even closer shows a much more active tail. The streamers widen and coalesce, and the tail becomes hollow in the centre. This is due to the enormous amount of gas and dust rising from the heated sunward side of the nucleus. The lower layers are protected from the solar wind by overlying material, and so they are able to expand sunwards for some way before being pushed aside and accelerated down the tail. The effect is rather like a fountain.

Comet Seki-Lines 1962 III passed within 3 million miles of the solar surface on April 1, 1962. Fig 3a shows the comet on April 3, when 13 million miles from the Sun, only 50 hours after perihelion. The comet was magnitude -2.5 , and even in bright twilight displayed a tail over 5° long. The tail showed this 'fountain' effect, with material in two layers moving down either side of the tail. By the 13th, the comet was magnitude $+3.2$, and was then 50 million miles from the Sun. The tail had settled down to a single layered stream, with one side of the bifurcated tail much brighter than the other, and the centre now really dark. As time went by, the bifurcation became less apparent, the tail becoming more diffuse and a circular coma developing once more.

On April 22, at a distance of 70 million miles from the Sun, the comet had faded to magnitude $+5.5$, and the tail had become broad and diffuse, being equally bright right across. (See Fig 3c.) As the tail became fainter, it developed a central brighter 'spine'. On May 3 (Fig 3d) the comet was magnitude $+8.0$ and 100 million miles from the Sun. These four drawings illustrate well how different a comet can appear at different times.

A diffuse tail frequently accompanies comets as they fade—even in regions where they showed no tail at all when moving sunwards. Of course, some comets fail to develop any tail at all, and there are some rare types of tail not mentioned here. This inability to predict what type of tail a particular comet will have is one of the joys of comet observing. No two comets are alike, and one just does not know what is in store until the comet is actually found.

Budding comet observers will have had an opportunity to see a bright object at first hand



Fig 3 Tail changes in Comet Seki-Lines 1962 III. From top, (a) 3 April mag -2.5 (b) 13 April mag $+3.2$ (c) 22 April mag $+5.5$ (d) 3 May mag $+8.0$. All drawn using binoculars and small telescopes

recently. As *Hermes* goes to press, Comet Honda 1968 c is expected to become a naked-eye object with a considerable tail during September, remaining visible all night. I hope you will try for this object, and that your first glimpse of a bright comet will persuade many of you to take up comet observing.

The Great Discoverers

What connects Giuseppe Piazzi (1746-1826) with Gauss's theory of motion, Bessel's heliometer, and the Astronomer Royal for Scotland? T L MACDONALD unearths coincidences surrounding Ceres

ONE does not at once think of Giuseppe Piazzi as a great discoverer. Popular books only mention him in passing as the discoverer of Ceres, first of the minor planets. One may indeed add that he was the first man to add a planet to the solar system, and know what he was doing; even Herschel thought Uranus a comet at first.

General histories of astronomy tell how J. D. Titius of Wittenberg noticed a coincidence in planetary distances, in a note to his translation of Bonnet in 1772. J. E. Bode suggested that a gap in the series could be filled by an unknown planet, and as his almanac was the *Yearbook of Astronomy* of the time, the sequence has been known as Bode's Law ever since. Baron F. X. von Zach, who for over 20 years edited *Monthly Correspondence*, one of the first astronomical magazines, made a guess at the elements of the orbit of such a new planet. To patrol the skies for it he organized his 'Celestial Police', including Olbers, Schröter, and the latter's assistant, Harding; to these was added Piazzi when he found the moving star that was Ceres.

Piazzi, a native of Ponte in the Caltelline, was educated by Tiraboschi and others, and taught in Malta and Italian cities until 1780, when the viceroy of Sicily, a Prince Caramanico, offered him the professorship of mathematics at Palermo. He found the Prince very willing to provide an observatory, an incongruous addition to the ancient palace of Saracen Emirs. Piazzi devoted three years to fit himself for his new duties, first with Lalande, and then with Maskelyne at Greenwich; there, he persuaded Ramsden with some difficulty to construct a great measuring circle, 5 feet in diameter, which has been described as "the most perfect measuring instrument hitherto employed by an astronomer". It was provided with magnifiers for reading off the divisions and was mounted over a horizontal azimuth circle, both improvements suggested by Römer.

Piazzi had realized that, as Bessel said, a knowledge of the places of the stars was the foundation of astronomy. He worked methodically from 1791 to 1814. His second star catalogue, a model

for his time, contained the places of some 7,600 stars; many of his numbers are still, for example, in Norton's *Star Atlas*. If Herschel surveyed the heavens as revealed in his great telescopes, it was Piazzi who supplied the fundamental data of astronomy. That is his claim to lasting fame.

On the first evening of the new century, 1801 January 1, while chasing up an error of Wollaston, Piazzi measured the places of 50 stars in Taurus. Repeating the work the following night, as was his custom, he noted that an 8th magnitude star had changed its position. He verified this on January 3. On January 14, the star reversed its motion; Piazzi had wondered whether it might be a comet, but it was behaving like a planet. On the 23rd he wrote to Oriani in Milan, and next day to Bode. Such was the postal service during the Napoleonic wars that the second letter reached Berlin on March 20; the first arrived in Milan on April 5. It has been noticed with amusement that the delay gave time for the philosopher Hegel to prove by logic that there could not be more than seven planets. But meantime the stranger had got too near the Sun to be observed. It could be lost again; and efforts to provide Bode with an orbit were of no avail.

This was when Piazzi's work produced a chain reaction. K. F. Gauss was then a young teacher in Brunswick. He had already worked on new formulae for elliptical orbits, and also discovered but not published the method of least squares, which could give the most probable result of a series of observations. With these new mathematical tools, Gauss was able to compute elements and an ephemeris. A month of bad weather gave Zach only one unconfirmed glimpse of the stranger. At last, on December 31, it was hard frost and Zach recovered the planet close to the predicted spot. It would scarcely be wrong to say that the contribution of Piazzi and his Ceres was to draw Gauss into the field of astronomical computing.

Piazzi had no share in the other three asteroids found soon after. Olbers discovered the second, Pallas, in 1802 by what we might now call Alcock's method, *i.e.* knowing the star fields so well as to

recognize a stranger. He also speculated that the two might be fragments of a broken major planet. By good fortune the next two discoveries were made near where the orbits of Ceres and Pallas intersected. Not only did this make the speculation plausible; it also made Gauss examine the effect of Jupiter on the newcomers from the point of view of their stability. He found a simple relation for Pallas which he announced in a sort of conundrum, a series of unexplained figures for which he never gave the solution. But that is another story to which perhaps we might return. The chain set up by Piazzi's discovery has taken us too far from him already.

Piazzi's unremitting labours with his measuring circle continued till his retirement; in fact, his later work was rather less accurate due to wear in the bearings of the instrument. In making his catalogues he noted the effect of the proper motion of a number of stars. In particular he pointed out the relatively rapid movement of 61 Cygni. And thereby hangs another chain.

In the year of Ceres, 1801, two old houses in a Munich alley collapsed killing all the occupants except a badly injured lad of 14. His name was

Joseph Fraunhofer of the Fraunhofer lines in the spectrum. The Elector of Bavaria helped him to train as an optician. His lenses were famous. Among his achievements was the Königsberg heliometer which Bessel used to find the parallax of the 'flying star' 61 Cygni which Piazzi had indicated. It might be added that it was another of Fraunhofer's instruments that Struve used at Dorpat to find the distance of Vega in the same years as Bessel worked. It was Bessel, and his assistant and successor Argelander, who finally superseded Piazzi's catalogues in the great Bonn star catalogue.

Admiral W. H. Smyth of the British Navy spent much time in the Mediterranean during the Napoleonic wars and afterwards from 1817 to 1824 made a great scientific survey there. He studied astronomy with Piazzi and afterwards wrote his *Cycle of Celestial Objects* which in turn inspired Webb to write *Celestial Objects for Common Telescopes*. He gave his son, Charles Piazzi Smyth, the name of the Palermo astronomer. Piazzi Smyth became Astronomer Royal for Scotland; he and his father and Piazzi are all commemorated on the Moon.

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Galaxies and Nebulae

Some planetary nebulae have central stars that are variable, and one is known to be a binary. M J HENDRIE (who took this month's cover picture) explains how planetary nebulae are photographed

IN the July 1967 issue of *Hermes* (Vol. 14, No. 4) we discussed the numbers and distribution of planetary nebulae. Some five hundred have been found in our galaxy, forming a cloud of objects strongly concentrated on the galactic centre like the globular clusters and Population II stars. They have nothing in common with planets, being gaseous nebulae surrounding very hot but usually faint central stars; many astronomers believe that they arise when stars become mild novae, and that after shedding matter that forms the nebulae they become white dwarfs.

In the autumn months the constellation of Lyra is well placed for observation from northern latitudes and the sky is again dark enough for some good views of galaxies and nebulae with small telescopes. The best known of the planetary nebulae is the Ring Nebula in Lyra which, although of much smaller apparent extent than the NGC 7293 in Aquarius pictured on the cover of the July 1967 *Hermes*, is sufficiently compact to be seen easily in good conditions with a telescope of a few inches aperture. Choose a dark, moonless night with Lyra nearly overhead for the best opportunity. A fairly high power, say 150 $\times$, helps to emphasize that this nebula is a ring and not a disk like the Owl Nebula in Ursa Major.

Changing aspect

The photographs show the changing aspect of the Ring Nebula in the light of different colours. The visual view corresponds with the red light photograph, the faint bands shown in yellow light being too faint to see visually, at least in telescopes of moderate size. The central star, which is of magnitude 14.7, will not be seen.

As the nebulae emit light at a number of definite wavelengths (and with little or no continuous spectrum like the Sun) it is possible to photograph them by the light of a particular energy state of an element. Thus the central part can be photographed at $\lambda 4686 \text{ \AA}$ (He II line). The intense ultra violet radiation from the very

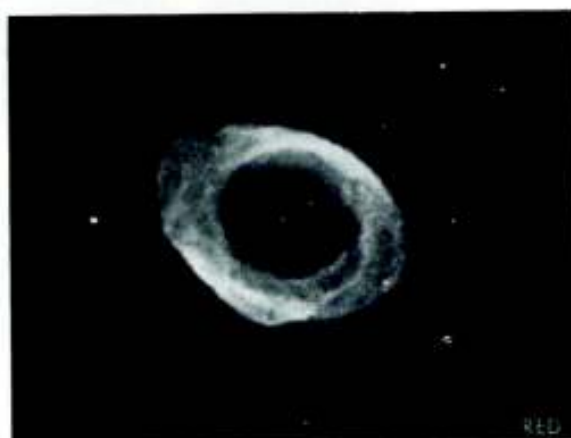
hot central star is sufficient to ionize all the atoms in the interior of the nebula and to impart an outward motion to them. Light is emitted when these ionized atoms recapture electrons. Depending on the atom (helium, oxygen and so on) so the distance from the central star at which they can recapture the fast moving electrons will differ, leading to the different shells of the nebula radiating in the light of a single element or type of atom. These monochromatic images may be obtained either by the use of filters that pass only a narrow range of wavelengths or by the use of the slitless or objective prism spectrograph.

Complete image

In a normal slit spectrograph each spectral line is an image of the slit in the light of a certain specific wavelength. When the slit is removed each wavelength will form a complete image of the object at that wavelength. In planetary nebulae the number of wavelengths at which a strong image is obtainable is small so that although some overlapping of images occurs this is not serious. Not only does this technique show the relative shapes and intensities of the images at the different wavelengths but it also shows the difference in size and thus the different distances from the central star at which the radiation is emitted. The four photographs in blue, green, yellow and red light may be thought of as images from a slitless spectrogram, although the detail obtainable by filter photography is greater in practice.

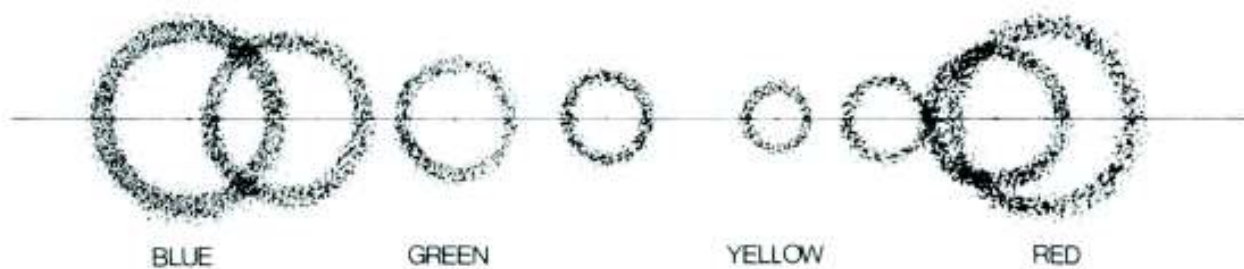
The Ring Nebula is marked on Norton's Star Atlas and the following data are from Becvar's Atlas Coeli Katalog.

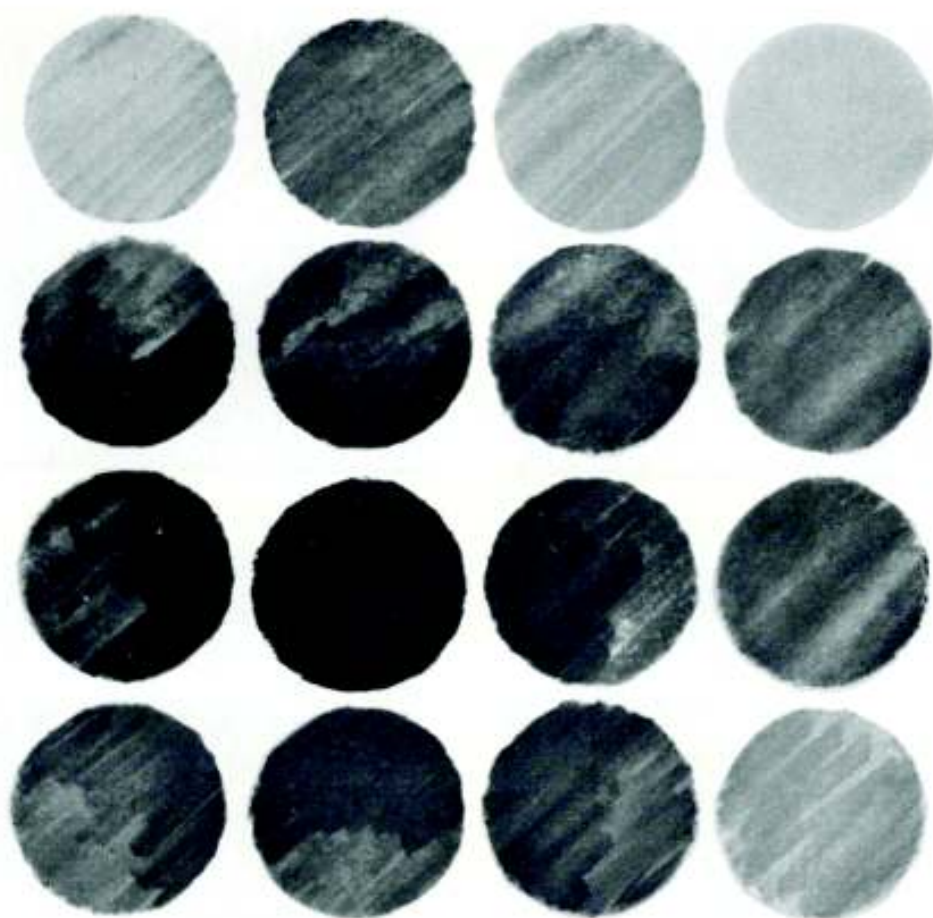
NGC 6720, M 57 (Ring Nebula in Lyra)	
RA 18h 51.7m	Dec. +32° 58' (1950.0)
Magnitude	9.3
Apparent size	1.3' $\times$ 1.0'
Linear size	0.6 light years
Radial velocity	-19.1 km/sec
Distance from Sun	2200 light years



NGC 6720, the Ring Nebula in Lyra, shows apparent change in shape when photographed in blue, green, yellow, and red light. The shell has a very complicated structure, owing to turbulence which is being caused by expansion of the gas and a general rotation of the entire nebula. 200-inch photograph from the Mount Wilson and Palomar Observatories

General appearance of a slitless spectrogram. Image sizes at different wavelengths depend upon the position in the nebula of the emitting material. The central star's strong ultraviolet output is degraded to visible light by atomic collisions within the nebula, making the gas envelope seem a lot brighter than the stimulating central star





SPHERES OF INFLUENCE

We believe there are no such things. To be more explicit, we believe that *literally* there are no such things. If it were really possible to draw a line around the influence of any particular phenomenon, the result would certainly not be a sphere.

By the same token, there is nothing absolutely cut and dried about the influence of *PLANETARIUM*—a relatively new phenomenon—except that it is extensive. Primarily it is devoted to the work of the world's leading amateur astronomers, but the material it contains is of certain value and interest to both professionals and amateurs alike.

Take the September issue. There is Sir Bernard Lovell on the new plans for Jodrell Bank. Dr T W Rackham on the first steps in making a telescope. Keith Hindley on the Pulsars. J S Glasby on the dwarf novae. Not forgetting an extensive news section, book reviews, and the Night Sky by Patrick Moore.

Planetarium No 6 (on sale December 20) will be just as good. Special price to JAS members 2s 9d Send to:

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Society Notices

ANNUAL GENERAL MEETING of the JAS will be held at Caxton Hall at 14.00 hrs on October 26. Amongst the speakers is Dr R. A. Hunter, Chief Assistant at the Royal Greenwich Observatory, who will give up-to-date information on the Observatory and the 98-inch telescope.

AMENDMENT OF CONSTITUTION AND RULES. Rule 4(4). A member shall cease to be a member of the Society if his annual subscription shall become *ten weeks* in arrear. The above amendment, changing the period of grace from six months, will be put to the AGM for confirmation. It is being implemented by Council to facilitate speedy collection of subscriptions and to prevent wastage of members' money on unnecessary printing. The rule change means that any member due to renew in September who has not done so by December 1 will be removed from our files and will receive no further benefits of membership. Similarly, those due to renew in March who have not done so by May 1 will be deemed non-members. In future, first reminders of subscription renewal will be given well in advance through *Hermes*, as in July this year. Those of you whose subscriptions are due this September are advised to renew now, as this is your final reminder.

SUBSCRIPTION RENEWAL RATES are 15s for one year, or £1 with Circulars. Please make forms of payment out to the JAS and send to the Assistant Secretary at 58 Vaughan Gardens, Ilford, Essex. If you are not certain when your subscription is due, please send a stamped, addressed card to the Assistant Secretary for information. Note: you may renew for up to three years in advance. Members desirous of leaving the

Society are requested to comply with Rule 4(5) and signify so in writing.

ELECTION OF COUNCIL. A ballot form is enclosed with this issue. Please use it to vote for the Council members you would like. It must be returned sealed and unsigned to the Secretary by October 25.

BOOK SCHEME. The greatest economy in subscriptions to *Sky & Telescope* is still available through the JAS. Members pay £3 8s for one year, £6 6s for two years and £9 2s 6d for three years. Non-members pay £3 16s, £7 2s 6d or £10 8s 6d. Send money to Mrs V. Longman, 65 Speer Road, Thames Ditton, Surrey, enclosing an s.a.e., please, for receipt. *Planetarium* magazine is available to JAS members for 11s a year (four issues), or 14s to non-members. Make cheques, POs, etc., payable to Planet Publications Ltd and send to them direct at 40 Grays Inn Road, London WC1, mentioning the JAS and quoting your JAS number.

JAS PICTURE SCHEME has expanded—so that now there are 21 glossy space photos to choose from. This is the complete list: 1. Ranger VII, crater Guericke. 2. Ranger VII, last complete frame. 3. Ranger IX, Ptolemaeus/Alphonsus. 4. Ranger IX, rilles in Alphonsus. 5. Orbiter II, Copernicus and Fauth wide angle. 6. Orbiter III, Kepler oblique. 7. Orbiter III, Hyginus rille. 8. Orbiter V, Tycho. 9. Orbiter V, rolling rocks in Vitello. 10. Orbiter V, Full Earth. 11. Mariner IV, Martian craters. 12. Orbiter II, Moon's far side. 13. Orbiter II, Marius Hills. 14. Lick Observatory telescopic view of Copernicus. 15. Orbiter II, Copernicus and Fauth telephoto. 16. Orbiter II, Copernicus interior—enlargement of previous shot. 17. Orbiter III, faults in Hevelius. 18. Orbiter III, Galileo and Cavalerius Hills oblique. 19. Orbiter IV, Moon's north pole. 20. Orbiter IV, Moon trough in close-up. 21. Surveyor V, soil analysis box on Moon's surface. All photos are 10×8 inches and cost 3s 6d each, post free, from G. S. Pearce, 1 Valletort Cottages, Millbridge, Plymouth, Devon.

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Sky Diary NORMAN WRIGHT checks the important events

Principal Phases of the Moon

All Times GMT

	OCTOBER	NOVEMBER	DECEMBER
Full	6d 11h 46m	5d 04h 25m	4d 23h 07m
New	21d 21h 44m	20d 08h 02m	19d 18h 19m

Lunar Occultations (Greenwich Predictions)

Date	Star	Mag.	Phase	Time	Position Angle (deg)
Oct. 2	29 Aqr m*	6.5	D	20h 43.1m	106
10	Chi Tau	5.5	R	22h 47.3m	298
Nov. 2	171B Psc	6.3	D	23h 44.8m	66
10	76 Gem	5.4	R	24h 53.8m	231
26	50 Aqr	5.9	D	20h 24.1m	351
(Grazing limit between Greenwich and Edinburgh—see note below)					
29	147B Psc	5.8	D	23h 55.5m	50
Dec. 1	19 Ari	6.0	D	19h 52.6m	63
3	Zeta Ari	5.0	D	05h 01.0m	105
3	104B Tau	5.5	D	19h 06.2m	75
6	49 Aur	5.0	R	24h 41.8m	311
16	40H Vir	5.1	R	06h 05.7m	341
25	20 Psc	5.6	D	22h 04.6m	89
31	BD +23° 563	6.1	D	04h 02.1m	83
31	Chi Tau	5.5	D	17h 35.6m	35

*m = mean position of double star

FROM TIME TO TIME the attention of observers has been drawn to the importance of keeping a close watch on occasions when a star is due to pass very near the limb of the Moon. It is unfortunate that in such marginal cases it is not possible to calculate a prediction even to the nearest minute. The information available (as given in the above list for 50 Aqr on November 26) is that the star will definitely be occulted at either Greenwich or Edinburgh, and that at some narrow region in latitude between these two stations it will just graze by the limb, possibly vanishing and reappearing more than once behind mountain peaks or crater rims. Great interest lies in determining this 'occultation limit' in latitude, and it is only necessary for an observer to state whether or not the star is seen occulted, with a note of his exact location in latitude and longitude. Timing the occultation, if one occurs, will of course add value to the observation; but if all the JAS members with a telescope at hand could give a "yes" or "no" at these times it would be very rewarding, and of great value to those concerned with research on the motion of the Moon at HM Nautical Almanac Office. Special efforts have been made by astronomers at Herstmonceux on previous opportune occasions to station observers at the expected limit of occultation of a star, with fascinating and very useful results. There has not, as yet, been any response from JAS observers, although there must be some who have had clear skies at the right time. With the scatter of our observers throughout Britain, a grand opportunity for combined effort to the good is being neglected. Even if you have not observed occultations before, and have no equipment for timing them, please help out if you can.

There are two occultations in the predictions for Edinburgh which have a grazing limit in southern England in this period (start watching well before the time given), and two where the limit is certainly north of London.

Lunar Occultations (Edinburgh Predictions)

Date	Star	Mag.	Phase	Time	Position Angle (deg)
Oct. 31	BD -7° 6012	7.3	D	20h 52.4m	118
	(No occultation in southern England)				
Nov. 28	BD -2° 6071	7.5	D	20h 27.0m	110
	(No occultation in southern England)				
Dec. 29	BD $+18^{\circ}$ 359	6.6	D	22h 22.9m	113
	(Grazing occultation in southern England)				
31	104B Tau	5.5	D	03h 28.7m	141
	(Grazing occultation in southern England)				

MERCURY moves between Earth and Sun at inferior conjunction on October 15. It may be found by the real enthusiasts having a clear horizon to east and south-east while it is near greatest western elongation at the end of October. For just the first few days of November the planet will be visible shortly before sunrise. This is the last chance in 1968 to catch a glimpse of Mercury in twilight. On December 7 it will move through superior conjunction.

VENUS becomes visible in the evening in November, though very low in the sunset sky. The situation rapidly improves in December, and at the end of the year the planet is setting nearly 4 hours after the Sun. On the evening of December 22 Venus will be close to the 3-day-old Moon, when the phase of the planet is still gibbous, but approaching dichotomy. The apparent diameter is increasing, and by December 31 is up to 19 seconds of arc.

MARS continues to improve in brightness and situation in the morning sky, but does not become what one could call telescopically observable in 1968. This is partly a consequence of Mars moving through aphelion (farthest distance from the Sun) on November 12. During this last quarter of the year the apparent diameter increases slowly from a little less than 4 up to 5.4 seconds of arc, with a consequent increase in brightness from magnitude $+2.0$ to $+1.5$. Moving steadily eastward, Mars is located in Leo in October, and in Virgo in November and December. As a guide to identification, the waning crescent Moon is near on the mornings of October 19, November 16 and 17, and December 15. Mars will be less than half a degree north of Jupiter on December 6, and passes 4 degrees north of Spica on December 16.

VESTA, the brightest of the minor planets, is at opposition on October 20, at a magnitude of 6.4. It will be found at this time as a star-like object moving westward some 3 degrees SSW of Alpha Piscium, though actually situated in Cetus. As it is only just beyond naked-eye brightness, a pair of binoculars will easily pick it out.

JUPITER becomes a dominant object in the eastern sky before dawn during October. Satellite IV (Callisto) is involved in some phenomena with Jupiter, as Earth is still close to the plane of the Jovian equator. The first of these is a disappearance into eclipse at 02h 29m on December 27. At the end of the year Jupiter is moving slowly eastward in Virgo, just below the celestial equator, and is rising before midnight.

SATURN is at opposition on October 15, and will be quite conspicuous in the south-east evening sky at magnitude $+0.3$. It is in Pisces, with no very bright stars near, and when in the south, at around midnight in October, reaches an altitude of 44 degrees as seen from the southern half of England. The ring system now presents an imposing spectacle, inclined to Earth at an angle from 11 to 12 degrees. The minor axis of the ring ellipse this year is equal to about half the angular dimension across the equator of Saturn. At the close of the year the planet is in the south at 18h 30m.

Elongations of Titan from Saturn:

West	October 5 and 21	November 6 and 22	December 8 and 24
East	October 13 and 29	November 14 and 30	December 16



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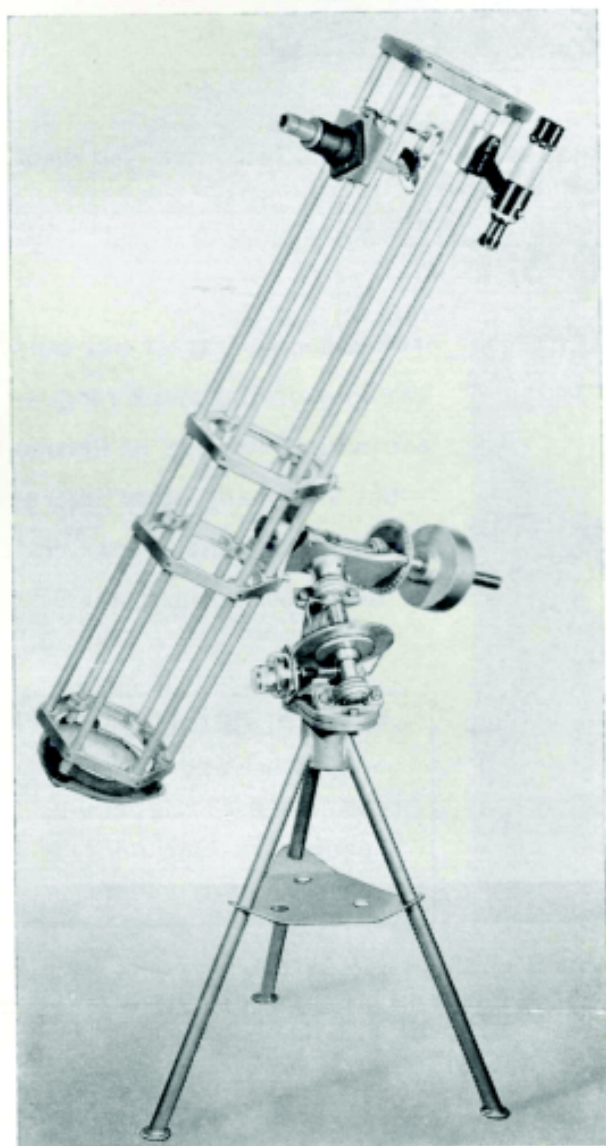
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