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In This Issue

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THE

STROLLING ASTRONOMER

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ANNOUNCEMENTS

ERROR IN OCTOBER, 1952 ISSUE. On pg. 144, line 11 the names of the astronomers Van den Bos and Hatanaka were misspelled.

SPECIAL OFFER OF THE REDUCED SIZE WILKINS MAP. From 1950 to 1952 we published in The Strolling Astronomer the H. P. Wilkins map of the moon, Second Edition, on a scale of about 38 inches to the moon's diameter. This map consists of 25 regular sections and several additional sections which show special regions of the moon. Our readers were very interested in this map, and back issues in which sections of it had appeared were soon completely out of stock. Therefore, new readers were unable to fill out their sets. Wishing to remedy this lack, we have now been able to arrange with our publishers, The Stevens Agency, 202 S. Broadway, Albuquerque, N. M., to publish the complete map as an attractive booklet. This little booklet will be very convenient for all observers of the moon to use at their telescopes. The sections of the map will be the same as they appeared in The Strolling Astronomer. Therefore, we make this offer.

THE WILKINS MAP AS A BOOKLET PLUS A ONE-YEAR SUBSCRIPTION TO THE STROLLING ASTRONOMER, EITHER NEW OR A RENEWAL, FOR FOUR DOLLARS.

THE WILKINS MAP AS A BOOKLET PLUS A TWO-YEAR SUBSCRIPTION TO THE STROLLING ASTRONOMER, EITHER NEW OR A RENEWAL, FOR SIX DOLLARS.

THE WILKINS MAP BOOKLET MAY BE BOUGHT BY ITSELF FOR THREE DOLLARS.

We should point out that the Wilkins map is much the most detailed map of the moon ever published. Mr. Wilkins is the Lunar Director of the British Astronomical Association, and his map is the culmination of a lifetime of intensive study of our satellite.

MORE ABOUT THE NEO-BRACHYT.

Mr. E. L. Pfannenschmidt writes that he made a couple errors in the article by himself and Mr. G. D. Roth in our December, 1952 issue. On pg. 167 the text of Figure 2 should read "To Correct = Apply Pressure to Tangential Plane 'T-T' at Back of Secondary." On pg. 170, line 40 read "tangential", not "sagittal."

Mr. Pfannenschmidt adds the following note, which should especially interest those readers who wrote us about the optical design of the Neo-Brachyt: "The secondary mirror rests with its front (silvered face) on the mirror cell at points 's' and 's' (Figure 2 on pg. 167 of December issue) only. Pressure is applied to its back by a metal bar running across its back from 'T' to 'T'. After the optics are collimated and adjusted in the finished telescope, this mechanical deformation of the secondary's tangential axis is performed but once on a suitable test object such as an artificial star, etc. Thus, the telescope and its optical system require no further attention after the initial deformation of the secondary."

CAVE-WILKINSON OPTICAL CO.

Such is the name of a new optical firm in Long Beach, Calif., Whose president is Mr. Thomas R. Cave, Jr. Better known as Tom to his many friends in the A.L.P.O. he is one of our chief observers and was our first Venus Recorder. An ardent follower of Mars, he has just contributed an interesting article called "The Canals of Mars" to the February, 1953 Griffith Observer. We extend our best wishes to our colleague in his new business. The Cave-Wilkinson Optical Co. offers telescope mirrors and other optical items for the amateur astronomer.

A NEW THEORY ABOUT THE ORIGIN OF THE SURFACE FEATURES OF THE MOON.

By Frederick Benario

The surface features of the Moon, so different from the ones on the planet Earth, have been since Galileo's time the subject of speculation with regard to their origin, formation and significance. Libraries have been written about the forces that produced the pock-scarred face of our satellite, and interpretation has never been able to explain all the surface features together as products of one identical force in conformity with a single all-embracing theory.

The most interesting and at the same time most numerous formations on the surface of the Moon are the craters. They are of such different dimensions that the smallest have their own name: craterlets, then the vocabulary progresses with increasing size -- diameter, not height -- identifying them as craters, ring mountains, walled plains etc. We can see through the telescope all sizes, craters from 2 miles or less across to 180 miles across, their floors either above, below or level with the height of the surrounding terrain. These floors may be smooth or may be covered with all kinds of formations, ridges, secondary craters etc. They are extremely numerous and fill the areas not inundated by lava like honeycombs, at many places one next to the other with almost no space left between two of them. Then we find real mountain chains on the Moon like on the Earth; but these chains are not numerous in contrast with such formations on the Earth; and, strangely, where these mountains exist there are very few craters. On the other hand, in the densest crater districts there are no chains of mountains. Nobody has so far explained this phenomenon. The surfaces inundated by lava were formerly also covered by craters, as one can still see some few rims and other parts of them protruding above the frozen lava level. Then we find the rills, rays and other surface features, things that have no counterpart on the planet Earth. But the very strangest objects are the craters within, on the side of, and on top of the ring mountains, everywhere where logic would not lead us to expect them to be, as if a gigantic hand in prankish playfulness had peppered the Moon with super-sized buckshot leaving these scars of incredible ugliness. The question since man began to observe, and especially since Galileo first saw the craters on the Moon: what is the Moon? has never really been answered.

I do not want to go into archeology, folklore and lovers' silver Moon symbols. In actuality the Moon is not bright at all. Her albedo (reflecting power) is only about 0.07, compared with 0.5 for the planet Earth, and is smaller than that of any planet except Pluto and Mercury. What I am trying to develop is a new approach to the explanation of all surface formations on the Moon, taking into account previous efforts by extremely clear-minded writers, who still could not bring everything we see on the Moon into such a mental focus that it becomes in its entirety a testimony to the last act in the evolution of our satellite before it became cold, hard, lifeless, set in its features for millions or perhaps the much propounded two billions of years.

One thing is certain. We earthlings have only two other "world" surfaces to compare the Moon with, and each is different. One is our own Earth, and the other is the planet Mars. Of Mars we know little. We see that Mars has no mountains at all and seems to consist of nearly level endless plains stretching from its north pole to its south pole and over all of its 360 meridians of longitude. How different from our Earth! But what do we know of our own abode? Very little again. Three miles down into the ground, ten miles up into out atmosphere, after that it's speculation.

Well founded and scientifically exact speculation based on observation of phenomena and the proper deductions from them, but the corrections to them and the new theories which are published from time to time show that our knowledge is still in the transitory stage and is not final yet. The same applies to the Moon, for the interpretation of its surface features there is no parallel on either Earth or Mars, thus forcing us to reconstruct things by an individual approach.

There are quite a number of theories extant about how the Earth with all the planets and their satellites came into being. Skipping all these different explanations, one phase in the assumed evolution of these bodies is common to all theories: the Moon, the Earth and the other planets were originally compact balls of fiery gases that condensed, formed a hardening outer shell around a still hot center of varying density, pressure and extent, and by further cooling off and shrinking of the surface layers produced on Earth the well known "wrinkles" now called mountains, ocean beds etc.

During this cooling-off process of the gases that must have been transformed into liquids, a magma, before hardening itself set in, enormous quantities of other gases that defied liquifaction must have been liberated. I speak of those gases which become liquid only in extreme cold, near absolute zero, like hydrogen, oxygen, helium, nitrogen etc. As the gravitational force of the Earth is greater than the escape velocity these gas atoms need to leave the Earth, our planet accumulated an atmosphere. Hydrogen and oxygen, perhaps under the converting impact of electrical discharge always occurring in hot stellar bodies, combined to form water and water vapor and hence the oceans. Many other gases like helium and an excess of hydrogen were lost to the atmosphere forever because the escape velocity of the atoms of these lightest of all gases was - and still is - greater than the pull of gravitation by the Earth trying to hold them.

This cooling-off period of the Earth's surface must have lasted millions of years and in fact is not over yet after some two thousand millions of years. We still have liquid-hot magma and enormous gas pressures just underneath our own lithosphere, the topmost shell of our Earth or its rocky crust. If there were not, there would not be any volcanoes, which are nothing but safety valves to release the dangerous excess pressure. And it is just these volcanoes which constantly emit a new supply of hydrogen and nitrogen, thus replenishing the permanently escaping supply of these gases in our atmosphere and keeping its quantity and quality about constant.

It must have been similar on the Moon. The Moon's gravitational pull is much smaller than the Earth's; in fact, these two forces compare as 6-1/2 for the Earth to 1 for the Moon. The latter is not enough to hold gases, even assuming they were the same gases as on Earth. The Moon's density is only 3/5 that of the Earth, its mass 1/81 that of our planet and its surface gravity 1/6; but its diameter is a little more than 1/4 that of the Earth. This is a misproportion. Not only must the center of the Moon, its core, be much lighter than that of our Earth, which is usually assumed to be iron under enormous pressure; but its "stones" or whatever they are must be more porous and perhaps analogous to our pumice, a volcanic product. Sedimentary layers of stone as on our Earth are impossible on the Moon because this requires for its formation water, erosion by water, rivers to carry this sediment to the ocean beds, all factors absent and always absent on the Moon.

The atmospheric envelope around our Earth acted always, and still does today, as an armor, protector and equalizing factor. The water vapor that produced the rains in times past, did the levelling-off process on all the original surface features. There is no trace left of anything that existed a billion years ago.

It would seem audacious to explain the surface features of the Moon when we have nothing on any large scale on Earth to compare them with and to make the proper deductions. I know there are two theories that offer explanations: The volcano theory and the impact theory. Of the two the impact theory, especially as propounded by Baldwin in his book The Face of The Moon is the more encompassing and logical; but it still comes wide of the mark. It does not account for anything but the craters on the Moon, and then Baldwin claims that there is needed only one meteorite of above average size every 100, 000 years falling upon the Moon to produce a crater; and in the 2 billion years since the Moon was formed the number of possible craters and their actual number would coincide. But in the beginning the Moon was liquid and no permanent features could be built up for, assumedly, one billion years; hence, only one billion years are available for producing the Moon's craters, chains of mountains, rays, rills, clefts etc. In spite of many parallels with "laboratory" experiments on Earth, like the craters produced by the bursting of artillery shells and air bombs, the impact theory puts too much strain on this one feature and explains nothing else.

Naturally, the Moon must sustain impacts from meteorites coming from outer space, just like the Earth; and on the Moon, where there is no atmosphere, no armor is present to reduce the force of the impact. The Moon must encounter daily, like the Earth, many millions of dust-size meteorites, perhaps even larger objects like we do from time to time; but since the time of Galileo no observer has seen any change on the Moon in nearly 350 years, except for the crater Linne which we see today much smaller than Maedler entered it on his map. The Moon seems to be the same as when she formed something like a lithosphere, a hardened, still somewhat plastic crust of varying thickness around an interior probably still producing gases. And here is the starting point to explain her surface features.

There is a parallel between the result of spectroscopy and the theory to be presented by me about the origin of the present face of the Moon. If we can reproduce the features of the Moon in the laboratory, all of them at the same time in one single operation under conditions similar to the ones of the period when the Moon was in her "formative" stage, in other words if we are able to "rebuild" the Moon under laboratory conditions, we will have a strong link in the chain of our assumptions. It is the same as with the lines of the solar and star spectra. When we have the identical line in our' experiments here on Earth, we know that the same atom emitted this line on any star in whose spectrum it is seen.

The writer of this article was fascinated by this idea. Innumerable telescopic observations and the study of photographs of the Moon in all her phases produced for him a mental picture at variance with the traditional explanations. He always had the feeling that what he saw were the remnants of bubbles, gas bubbles on an effervescent surface of low vicosity, but identical with the bubbles in a soapy solution when agitated, where the bubbles are side by side in uninterrupted expansion. His idea was that the surface of the Moon did not become hardened in a day, a week or a century, but that it took a long time to convert the surface of the gaseous mass into a boiling liquid, which process might have been repeated many times as the surface dissolved again wholly or in part into the original gas, whenever the temperature in the fiery gaseous ball rose or fell somewhat This process I visualize somewhat as analogous to what we observe frequently on our Sun. But finally the Moon did get a liquid layer, which in turn must have become plastic.

Even the plasticity led through innumerable steps into full hardening. Inside this plastic shell the atomic furnace was still at work and perhaps is still today to some extent. As this ball could not hold the gases emitted because the gravitational pull was smaller than their escape velocity, no protecting atmosphere was ever developed on the Moon; and it is quite possible that the Earth's atmosphere was enriched by great quantities of gases from the Moon. The Earth, protected by its own heat-retaining gaseous envelope, may have cooled more slowly than the Moon, which was in direct surface contact with temperatures near absolute zero. It is perhaps for this reason that our own planet never had ring mountains, but instead oceans; and whereas the Moon relieved her inner pressure by gas emissions on a grand scale, our Earth had volcanic activity and mountains produced by surface shrinking and sidewise pressure. I know that the Moon also has mountains, great chains with thousands of peaks; but my experiments show they were produced by pressure from underneath, a lifting-up process, and not by pressure of shrinkage to accomodate the same mass of material to a smaller surface.

I started my experiments for lack of a better material with plaster of Paris but did not use water, employing for the object of gas-liberation a bottle of soda pop. The liberation of gas was too short and was over before the plaster hardened. Nevertheless, I got a few ring mountains, remnants of bubbles with steep inside walls and inclined outside ones, some craterlets and some rills. Next I replaced the soda pop with Peroxide of Hydrogen. Here the results were better: Many more mountains, their rings of either circular or irregular form like Clavius on the Moon. Still, this was not the answer. In order to have still more gas I mixed the plaster of Paris with Peroxide of Hydrogen but put into the "magma' another gas-producing agent, a few tablet of Alka-Seltzer. These experiments were more satisfactory, especially since I arranged the plaster of Paris in a thick layer on one side of a plate and in a thin layer on the other. The production of gas was voluminous; bubbles formed and disappeared endlessly. I obtained ring mountain next to ring mountrain, depressed areas with no mountains at all – on the Moon they might have been filled in by Magma (lava), and on the side where the layer of plaster was thin there appeared chain next to chain of mountains like the Carpathians or the Alps on the Moon. Things came and went, but when finally the plaster had hardened the latest features to appear became permanent and could be examined later and in detail. It was found that the material of the chain mountains was much more porous and brittle than that of the ring mountains. Another feature became evident: Just as on the Moon, where the chain mountains developed there were hardly any ring mountains, and vice versa. Furthermore, craterlets were present in great numbers, and frequently, just as on the Moon, one next to the other in a row, like soldiers placed by a drill sergeant in a line. In one singly instance I even got a central peak within a ring mountain after the bubble had burst. The gas-well in the center had become clogged; but the gas pressure from underneath shoved material ahead of it along part of the old path, and on the tip of this central cone a tiny craterlet appeared, similar to the description by H.P. Wilkins in The Strolling Astronomer of July 1952, page 95, of the crater Aristarchus.

Still later I tried several admixtures to the plaster of Paris, but the results were the same. When I was able to speed up the hardening of the plaster of Paris less gas was needlessly lost; and I secured craters even on the rims of other craters, all kinds of wild and fantastic formations just like we see on the Moon, and, best of all, several unexploded bubbles. After complete hardening I carefully placed on the top of one of these intact bubbles a little finely ground graphite and heated the whole, which was on a pie dish, on a gas stove. The heat expanded the gas inside the bubble, the bubble burst, the graphite was strewn around, and lo and behold it looked like the rays around Kepler and Copernicus.

I admit my experiments were crude, and one's wife's kitchen cannot compare with a university laboratory. There must be better materials for the purpose of repeating these experiments than plaster of Paris and better gas-producing agents than tablets of Alka-Seltzer. Still, my experiments have shown the way; and I visualize much clearer models from more competent hands. The Physics Laboratories of Universities are the places where this work ought to be done.

These experiments lead to further deductions. If we visualize the boiling lava - most likely of different composition than the present lava on Earth - repeatedly eating-through a plastic top layer, or the sinking down of parts of this top layer, we have the conditions under which the maria of the Moon were filled in. But let's take one step more and go deeper into conjecture. Kepler propounded: Inter Martem et Jovem planetam interpousui. This planet must have been there. Today, in its place we have thousands and perhaps hundreds of thousands of planetoids. That their orbits today have all kinds of angles, mean distances from the Sun, inclinations and eccentricities is surely either produced by the perturbations of the major planets; or else at the moment of the explosion of the parent planet the fragments kept the direction into which they were projected according to Newton's First law of motion. Perhaps both influences, perturbations and rectilinear motions, were combined. This is merely a postulate of the event. [The perturbing influcence of Jupiter greatly affects the orbits of the asteroids. - Editor.] The explosion itself may easily be visualized by remembering the gas bubbles on the Moon. Let us assume that the planet between Mars and Jupiter, was already much cooler on its surface than the Moon at the time of our discussion, also that its top surface was less effervescent. Inside its hardened lithosphere the atomic furnace was still going full blast. There might never have been bubbles but a flat surface such as we see on Mars. Also this lost planet could not have been larger than our present day Moon, if indeed nearly that large. With the inside pressure of the atomic cauldron reaching the danger point and no bubbles possibly any longer on account of the already hardened surface, the whole planet blew up; and its pieces still float around between Mars and Jupiter and sometimes come dangerously close to our Earth. To one of the nastiest of such pieces that one day can really someesault into our Earth we gave the affectionate name Eros. Also Hermes, which comes still closer to us at its perihelion, we could easily dispense with.

The gases that produced the gigantic bubbles on the Moon must have penetrated her stony layer like water does a porous sponge. There cannot be stones on the Moon as we know them; for to form sediment water is needed, and the Moon is lighter than the Earth as already explained. But may these gas-filled stones, whatever they are, give a further clue to the origin of the comets and their tails? The deducations can be endless.

There may still be emission of gases on the Moon. Details on the floors of some craters are at some times prominent and at other times completely invisible even under identical observing conditions on Earth, which different visibility of details might be caused by a thin, light, reflecting layer of gas. This assumption might not be far fetched since some lunar observers have already discovered traces of a lunar atmosphere in some craters. It may be assumed that this gas production is periodic or intermittent and not continous, analogous to volcanic discharges on Earth. With the escape velocity of gas atoms on the Moon only 1-1/2 miles per second we shall have periods on the Moon when at some places a little reflecting gas layer is hiding details from us, whereas at other times a complete vacuum exists; and details hidden for many years since a former observation stand out clearly again. There are many examples of this phenomenon. Perhaps the Moon is not such an old girl after all and has still some spark of life left.

In conclusion I would like to give the new theory a name, the theory of bubbles in a nearly hardened plastic shell on the Moon. In contrast to the volcanic theory that could not explain the oversized ring mountains or the impact theory that also has its shortcomings I call my theory which explains, even by experiment, all the surface features on the Moon at the same time the Bubble Theory. The experiments described in this article and readily repeated everywhere produce not only the mountains, ring or chain, but also the rills, clefts, depressions for the maria eta. And what we see today on the Moon is nothing else but the final coalescence process of about a billion years ago perpetuating the final stage of the events which accompanied the change from the effervescent surface into a hardened surface layer, analogous to the lithosphere on Earth. The Moon may help us to understand our own Earth better.

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FOOTNOTE BY EDITOR. We express our thanks to Mr. Benario for his thought-provoking contribution to a subject of perpetual and considerable interest. We shall be glad to hear from our readers what they think of the "Bubble Theory" and shall try to publish the more interesting contributions in future issues. Mr. Benario will welcome correspondence about his article; his address is 151-10 State St., Flushing 54, New York.

SOME STELLAR EXERCISES FOR PLANETARIANS

by James C. Bartlett, Jr.

A short time back a gentleman of the Fourth Estate was examining the moon through my little 3.5-inch Newtonian; and to judge from his exclamations and remarks he was having a very good view of it. One thing which he said inspired this paper, a remark to the effect that the longer he looked the more he saw. Which brings us to another matter.

It seems to have been agreed among my friends that I must possess the keenest sight since Percival Lowell; and among my foes that I should have my head examined. The former, I am sorry to tell you, are very wide of the mark; and the judgement of the latter I must leave to the charity of history. My complete optical pathology would be out of place in a journal such as this; but sufficient to say that I am so myopic as not to be able to recognize a friend from across the street (unless I am wearing my corrections); that my right eye is slightly astigmatic; and that each eye has a different focus. My natural optical endowments, therefore, are something less than phenomenal.

How is it then that I confidently record delicate planetary detail with only 3.5 inches of aperture? Details which should be visible only to 6 or 8 inches. The answer is that I don't - though my friends appear to labor under such a misapprehension. Manifestly, 3.5 inches cannot show details just within the grasp of much higher apertures. What I do is to record details which are visible to 3.5 inches, but which may be missed if one does not possess a certain visual ability. Visual ability, one should note, is not the same as visual acuity. Visual ability may be defined as competence to see all that may be seen in any given circumstance. Visual acuity is the measure of one's light sensitivity, and beyond the obvious fact that without the latter the former could not exist, there is no connection between the two. Visual ability may be acquired, whereas visual acuity is a gift of Nature. Either one has it or one doesn't. Most of us possess it to a reasonable degree, even such myopic fellows as myself; and hence the first order of business for a serious observer is to improve his visual ability.

To this end it is first necessary to know what to do and how to begin; so the writer proposes in this paper to outline a course of visual training which has been found very beneficial, and to list the equipment which the student will find necessary. The training course itself is neither arduous nor remarkable, and indeed provides a pleasant diversion for leisure moments. Moreover, if faithfully followed, a marked improvement in visual ability is certain to follow; and this improvement will be translated at the telescope into the ability to see faint details which hitherto had been quite invisible. It is not too much to say that few suspect the full capabilities of their telescopes, whatever the aperture, until such a course of visual training has been undertaken.

Let us begin with the equipment needed for a really adequate course in visual training. This is not extensive and is as follows:

1. Low power optical assistance; a pair of opera glasses, Galilean field glasses, or prism binoculars.

2. A copy of Norton's Star Atlas and Reference Handbook.

3. A copy of the Skalnate Pleso Atlas of the Heavens.

4. A copy of the Yale Catalogue of Bright Stars.

5. Scratch pad and pencil.

6. Flash light.

7. Copy book for the permanent record.

Since the most expensive and most important item on the above list will be the optical equipment, we shall consider that first. If nothing better avails, a good pair of opera glasses will serve to a limited extent. I have enjoyed some very pleasing views with such glasses; but their light grasp is low and they will do nothing with stars much below 5th magnitude.

Galilean field glasses, king-size versions of the former, will be much more useful and have the advantage of larger objectives. Glasses of this type have the further advantage of relative cheapness; but the field is not well illuminated and definition falls off towards the edges.

If the budget permits, prism binoculars will be found much superior to either. The field is brilliantly illuminated and definition holds to the very edges. But if such a glass is selected one should take care not to buy with a view to power; for power is not needed in the exercises to be described below, and every increase in power is apt to mean an increase in weight which will make the glasses difficult to hold steadily. Other things being equal, the prism binocular should be selected with a view to obtaining as large objectives as possible. Perhaps the most generally useful size is 7x50; for in this type power is high enough to show lunar craters distinctly and the objectives are very nearly 2 inches in diameter. If obtainable, coated optics should be specified. The field in 7x50 prism binoculars is large and bright, and such a glass will show stars down to 10th magnitude in a city sky.

The Norton Atlas may be obtained on order through any reputable book dealer, especially those who specialize in scientific works; but if it cannot be readily found a very good substitute may be had in A Beginner's Star Book, by Kelvin McKready (Edgar G. Murphy), published by G. P. Putnam's Sons. The star maps in this work are very clear and easy to follow and include stars down to 5th magnitude, while the hemisphere maps in the back of the book show a few additional stars down to and below 6th magnitude. Chief advantage of the Norton Atlas is in the greater number of faint stars included down to 6th magnitude and dimmer.

The Skalnate Pleso Atlas is obtainable from the Sky Publishing Corporation, Cambridge 38, Mass. It is much more complete than Norton's Atlas in regard to very faint stars and carries them down to 8th magnitude. It is, however, a little difficult to use for those unfamiliar with constellation work as the scale is very large. In a pinch one can do without it.

But the Yale Catalogue is practically indispensable. This notable compilation includes all stars down to 6.5 magnitude, and a few noteworthy ones still fainter. Not only is the apparent magnitude of each star given but also its spectral class. The last feature is invaluable for those wishing to improve their color estimates, and more than any other feature makes the work a "must" for the visual trainee. It may be obtained from Yale University Observatory.

Items 5, 6, and 7 may be had at any dime store and need no comment, though it may be said that in using the flash light a disc of red cellophane may be placed over the lens in order not to dazzle the eye in the darkness of the observatory. If this is not obtainable very good results may be had by using a flash the cells of which are nearing extinction. The weak light from such a flash will be sufficiently bright to illuminate the maps, and to enable one to make notes, and yet not dazzling to the eye.

Although for our purposes it is not necessary to know the diameter of the field of view of our glasses, some may wish to have this datum. And if the candidate is a little hazy on the arithmetical operations involved, the figure may be obtained directly as follows: Sweep around near the meridian until a field is found in which two fairly bright stars close to the celestial equator exactly occupy opposite edges of the field, and on a line running horizontally through its center. Next, identify the stars from an atlas and then look them up in the Yale Catalogue, where the stars are listed in order of increasing right ascension beginning with 0^h. Finally, find the difference in right ascension between them. We shall assume that the difference found is 20 minutes. Now a difference of 1^h in r.a. would equal 15^o and 20^m is equal to 1/3 of an hour.

Therefore we multiply 15 by 1/3 and the product or 5 is the diameter of the field. In short our glasses have a 5^o field. The rule is that whatever the difference in r.a. between two stars at opposite sides of the field, this difference multiplied by 15 gives the field diameter in degrees. If the stars are not near the equator, we must in additon multiply by the cosine of the declination.

All equipment having been obtained, we shall next consider the nature of the exercies to be undertaken. These will consist of minute examinations with our glasses of all principal star fields in the twelve zodiacal constellations, each field to be centered on one star of a constellation in turn until all Bayer letter and Flamsteed number stars of that constellation are exhausted. We then move eastward into the next zodiacal constellation and so on around the heavens and back to our starting point. The complete course may take several years, allowing for breaks in the weather, the time lost when the moon, from quarter to quarter, is in or near the constellation, personal pressures, and other unavoidable delays. But as the training may go on concurrently with our regular planetary work, its benefits will soon become apparent and the time factor becomes unimportant.

Choice of a starting point will depend upon the season in which we begin; but in all cases it will be in a constellation which is on the meridian at a convenient hour and in a night sky. Insofar as circumstances permit, our study fields should always be on the meridian, as the stars are then at their greatest altitude above the horizon. This is a very important factor for low, southern constellations, such as Scorpius, as viewed by northern hemisphere observers.

We are now ready to begin on our first study field, and for this purpose we need in the observatory - or the back yard as the case may be - only our glasses, the Norton Atlas, the scratch pad and pencil, and the flash light. On the scratch pad we have previously inscribed a cricle 4 inches in diameter, which is to represent our binocular field; and on this pad also is to be entered date, time, transparency, seeing, and such notes as may be thought necessary. If the observer is totally unfamiliar with constellation work, as many planetarians are, a planisphere may be added to the equipment listed above. This will show the aspect of the sky for any hour selected and far better than the maps, especially in regard to the meridional aspect of whatever constellation we select as starting point. This last, by the way, circumstances permitting, should be large and well sprinkled with bright stars so that the novice may find his way around without too much difficulty. Scorpius, Sagittarius, Taurus, Gemini, and Leo are all good starters. Libra is a little indefinite; Capricornus, Cancer, and Aries a little too dim and inconspicuous, though Aries does possess one second magnitude star. Aquarius, Pisces, and generally speaking, Virgo are not only dim but sprawling and incoherent. They had best be left until more experience is gained.

Currently, the writer is starting on a refresher course using 7x50 prism binoculars with coated optics and having a field of view of nearly 6°. Let us assume that our candidate employs similar equipment and that he begins with Scorpius. Since his work will consist of systematic and orderly examinations of individual fields, each centered on a particular star, he will begin with the Alpha of the constellation, or Antares. Bringing this star into the center of his field, his purpose is to make a map of all stars visible to him in that field; and for this purpose he used the circle inscribed on his scratch pad, putting Antares in its exact center. As each star is dotted in, he should affix to it a pencilled number representing the estimated magnitude. Marginal notes may be made of color estimated. He should also watch for any close optical doubles, to this end examining each star in the field by turn.

If he has not done much star sweeping our candidate at first probably will see only Alpha, Tau, Sigma - all conspicuously bright - the little star marked 22 in the Norton Atlas, due north of Antares, with an apparent magnitude of 4.87; Rho Scoprii (mag. 4.87); Omicron Scorpii (mag. 4.7) and possibly the little 6th mag. star about 0.45° due east of Antares. If his color sense is good he may notice that this little 6th mag. star is a fine orange-red. It is assumed that the observer has a city sky; in open country he will do much better. After a while he will begin to distinguish little streams of much fainter stars, curving around Antares on the west. These will range from 7th to 9th magnitude. After his eye is able to take in these faint stars, he may suddenly notice that the little star, 22, has an 8th mag. companion; and that Rho has a similar companion about one magnitude brighter.

Having completed his map, the observer is now ready for his paper work. Gathering up map, notes, and his Norton, he may then retire to his den where the Skalnate Pleso Atlas and the Yale Catalogue are waiting. All the brighter stars in his field will be readily identified; but it is now his purpose to identify so far as possible the very faint stars. On looking into Norton he will find many of them depicted there, and thus he will be able to check the accuracy of his map; but some will not be shown. This is only because they are below the limiting magnitude of the Norton map, and the purpose of the Skalnate Pleso charts now becomes apparent; for most of the missing stars will be found there. A few, however, will still be missing; and these will be the very faint stars below even the 8th mag. limit of Skalnate Pleso. The chance that one of the missing stars may actually be a nova is incredibly remote, but not impossible, and it is one of the many charms of the course that such a discovery is always possible. To this end, our observer may wish to keep a watch on any objects he cannot identify; and so he receives additional training and may quite possibly come up some time with a comet at the least. He may also accidentally record variable stars and asteroids, the latter being identified by their motion.

Some of the faint stars will have Flamsteed numbers in the Norton atlas, and these may be looked up easily enough in the Yale Catalogue; but many will be without designation. The brighter of these, i.e. those not below 6th mag. may also be found in the Catalogue after a little preparation. First the r.a. and declination may be obtained from the map; then the corresponding r.a. is turned up in the Catalogue and run down until the nearest possibly declination is found. This will be the star and so its apparent magnitude and spectral class may be obtained.

In this manner the observer obtains his

percentage of errors in estimating the magnitudes and colors of very faint stars, and this is the principal purpose of the course; for it will be found that with persistence the percentage of error will become less and less, which means that visual ability is becoming greater and greater.

In regard to color estimates, it should be noted that not much can be expected for stars much below 6th mag; for for stars from 4th to 6th mag. it is possible to make very accurate estimates of color. The percentage of error may be found from the Catalogue, by comparing the spectral class of the star with the estimated color. As with magnitudes, it will be found after a while that color estimates are becoming increasingly accurate. The observer is beginning to learn how to see faint colors. For those unfamiliar with the relation of spectral class to color the following information will be useful. In the Harvard classification of spectral types there are eight major divisions or classes: O, B, A, F, G, K, M, and N. This is the classification used in the Yale Catalogue. O stars, or Wolf-Rayet stars, are always white or bluish-white; B stars, the helium or Orion stars, blue to bluish-white; A stars white to bluish-white; F stars, white to yellowish-white; G stars yellowish to pronounced yellow; K stars, yellowish-orange to orange; M stars, orange to deep orange-red; N stars, or carbon stars, deep red. So if our observer estimates the color of a 5th mag. star to be white, and on looking it up in the Yale Catalogue discovers it to be a K star, he will know that he has made an error and will examine the star again. Sufficient to say that by such painstaking comparisons he inevitably begins to improve his visual ability, and presently he will find his color estimates becoming more and more accurate. This improvement will stand him in good stead in his normal planetary work, and he will be surprised to see faint tones of planetary colors which hitherto had appeared only as shades of gray.

Next night our observer is ready for his next field, so he begins with the Beta of the constellation; and so on through Gamma, Delta, and all the rest until the Bayer letters have been exhausted, when he may continue through the Flamsteed numbers until the constellation has been worked out. He is then ready for the next one and so completes the zodiacal circuit. The actual time per day consumed in this program is not great. In a very rich constellation with many faint stars, it will probably not be possible to do more than one field per night; and this may take up to an hour. But in a barren constellation one may be able to do several fields per night.

Such is the method I have employed for many years, in keeping my visual ability sharpened; and if such a program is faithfully and systematically followed the improvement in anyone's visual ability will be nothing less than astonishing.

This does not mean, of course, that after a year or so of training a Three-inch telescope will show what a 6-inch telescope will show. Unfortunately one cannot train the telescope. But it does mean that the observer will see more and more of what his 3-inch instrument can show; and he will realize that it can show very much more than he had suspected.