NATIONAL SCHOOL
SAILING ASSOCIATION

THE CELESTIAL CLASSROOM

Curriculum Development Paper No 8

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A School Project in "Undifferentiated Learning"

This exercise has been carried out by top juniors and young secondary children with varying degrees of polish and usually as part of a much wider series of investigations into astronomy, sundials and so on. It has often grown out of a desire to "learn the stars" , the use of a flannelgraph to depict the Great Bear or the Northern Crown or just from a visit to a planetarium.

The project is to mark the "fixed" stars in their proper relative positions on the classroom walls and ceiling and so to mount a globe that the visible sky maybe delimited at any time of the night in any place and on any night of the year. (See Figure 1).

Flowing from this central theme, the children can decorate the constellations with full scale drawings or paintings of the mythological creatures whose names they bear. Much reading and use of reference books becomes an important part of the work and , with encouragement, descriptive and creative writing can no doubt grow from the children's discoveries.

Ideas in science, geography and mathematics include a variety of three-dimensional concepts: planes and their intersection, sidereal and sola time, the use of angles as a measure of rotation and to locate objects in space, the relationships between a "fixed" celestial sphere and a rotating and orbiting earth, the calendar, the seasons and, for the really able, even such abstruse ideas as the "obliquity of the ecliptic" or the "precession of the equinoxes."

That the children will have learned to recognise many stars, will be a useful bonus; the possibilities for historical, scientific or othical lessons to be drawn from the children's reading, from folk-lore and from classical mythology are as wide as the teacher cares to make them and the children's interest will sustain. Indeed, with the exception of physical education and, possibly, of the music of the spheres , there is almost no partof the curriculum witch does not at least rub shoulders with this project.

Materials needed (not all at once)

Stars These are best made from coloured sticky paper and of different sizes, 2" diameter will serve for bright stars, lf" for those of lesser magnitude and so on. (The ordinary gold and silver stars are really too small to show up well).

A simple sighting instrument (see figure 2 for sketch and instructions for making.) A star catalogue or nautical almanack (available from public libraries).

A star map or star globe.

Reference books including mythology biography, history and astronomy to suit the children's ages . These should include some which show shapes of the constellations . (A discussion with the local children's librarian will help).

A reel of cotton.

A large sheet of paper marked with the zodiac and the months of the year. (See figure5)

A large reel of coloured Scotch tape.

Thin cards for making time dials, horizons, etc. (See figure 6 and 5).

Suction cups off old soap dishes or driving mirrors et. A battery and torch bulb.

A pound or so of plasticine.

Method

The first step, after having got children accustomed to both using a protractor and to copying constellations from a book (or better still from observation) on to a flannelgraph or paper "sky" is to prepare a list of co-ordinates for a single major group of stars. (Orion is a very good one to start with).

Your star catalogue will give the position of stars in degrees of Declination, north or south of the sky's equator or equinoctial. This is the equivalent of latitude.

Star's name	Dec.	R.A.	S.H.A.	Mag.
*Canis Minoris (Procyon)	5¼¼0 N	112°	248°	0.5
Canis Minoris	8½° N	111°	249°	3.1
*Geminorum (Castor)	31° N	114°	246°	1.6
Geminorum (Pollux)	28 ° N	116°	244°	1.2
*Orionis (Betelgeuse)	71° N	88°	272°	Var.0.1 -1.2
Orionis (Alnitak)	1°S	85°	275°	1.9
Orionis	0 °	83°	277°	2.5
Orionis (Alnilam)	1°S	84°	276°	1.8
* Orionis (Rigel)	8°S	79°	281°	0.3
Orionis	5°S	84°	276°	2.9
Orionis	9 o S	870	273°	2.2
* Canis Majoris (Sirius)	16°S	101°	259°	-1.6
*Canis Majoris (Adhara)	28°S	105°	255°	1.6
Orionis (Bellatrix)	6°N	81°	279°	1.7
* Tauri (Aldebran)	16°N	68°	292°	1.1
Tauri (Elnath)	29°N	81°	279°	1.8
Tauri	21°N	84°	276°	3.0

If the catalogue is an old one, it will give the "longitude" in degrees of Right Ascension (or R.A.). Remember, looking down from above, this is measured left handed (to the eastward) from the starting point.

A modern almanack may give the "longitude" as Sidereal Hour Angle (or S.H.A.). Remember , this is measured right handed (to the westward) from the starting point. Here are enough stars in the constellations of Orion to complete the hunter with his dog, his sword and the bull he is fighting.

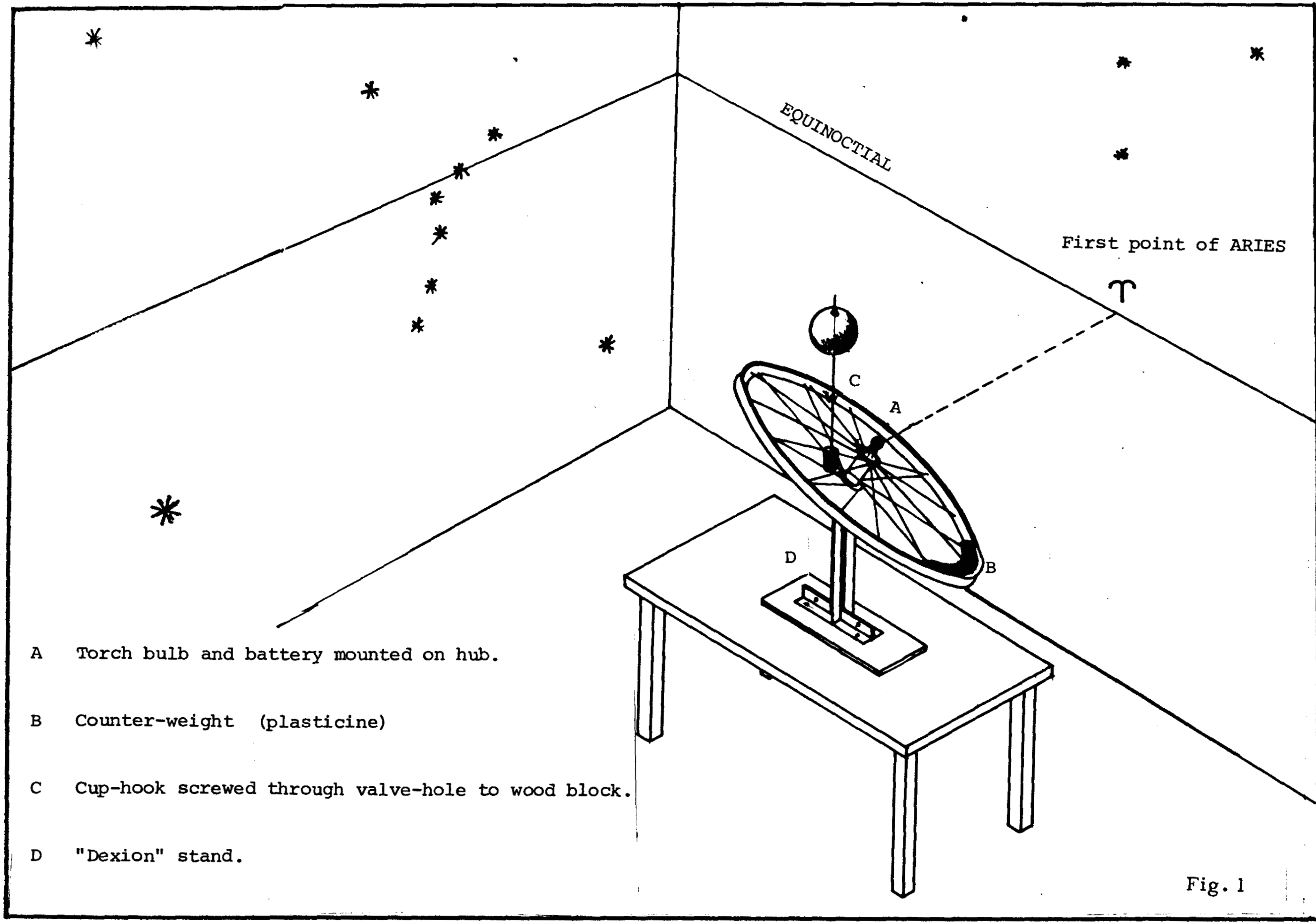
As a first step, children might plot only those stars marked with an asterisk and put the rest in by eye so that the "catalogue"you could give them would show only those stars.

Aside

In passing, there are.some curiosities of history here: each star has a "catalogue name" in Latin with a Greek letter to distinguish it from the other stars in the same group. The brightest stars have, as it were, a personal name too, often Arabic in origin (e .g . Aldebran) or sometimes Greek (e .g . Castor and Pollux (the Heavenly Twins). There are some lovely stories about all these characters.

Another relic of the past is the way in which the brightness of stars is recorded. In the old days of astronomy with the naked eye, very bright stars were described as being "of the first magnitude" and less bright ones as being of the second.' It takes very sharp eyesight indeed to see stars of the fourth magnitude. This system is still in use except that decimals have been introduced to measure more exactly. The lower the number, the brighter the star; a very bright one indeed might have a magnitude of 0. The brightest star in the heavens (Sirius) shines so strongly that it has to be given a magnitude of -11: For the children use the old words "first magnitude", "second magnitude" etc. and simply say that Sirius is about twice as bright as a first magni-

BICYCLE-WHEEL ORRERY   GENERAL ARRANGEMENT



A Torch bulb and battery mounted on hub.

B Counter-weight (plasticine)

C Cup-hook screwed through valve-hole to wood block.

D "Dexion" stand.

Fig. 1

tude star . Two or three sizes of paper star will do for most purposes with an extra large one for Sirius.

Method (Continued)

Put a table in the middle of the room and on it stand a solid box so that when the angle measurer is stood upon it, its centre is about 15" above the table top. (Make sure that the top of the box is level by lining it up with the walls all round.) An alternative would be of course, to make the angle measurer sufficiently high so that the centre would be as high as the orrery. This might however limit its use for other purposes.

Set the pointer of the measurer at 0° and line it up to a point on the wall which may be marked with chalk. Turn it round in Sidereal Hour Angle about 10° and make another mark and and so on right round the room. When these are joined up, the sky's equator or "equinoctial plane" can be drawn in. Children have great fun striking a line with chalked string and incidentally may learn a little about both mathematics and the English language. "Linen" is the old plural of "line" (like "hosen" and "hose" or "children" and "child"). If you pronounce "stretched linen" exactly as it is written, letter for letter, it sounds very much like "STREK-ED LINNEN" and the origin of "straight line" becomes apparent, it also sounds like "STREK-ED LINNER" and is no more and no less, than a stretched linen thread.

Having got the equinoctial marked in with chalk, it may be worth-while to mark it permanently with coloured Scotch tape as it will be needed as a reference plane later.

A point on the equinoctial at the centre of a long wall of the classroom and exactly opposite the measurer on its table should next be marked with the sign for the First Point of Aries (see figure 1) - from this point all "longitude s"will be measured.

Set the measurer at 0° declination and 0° S.H.A. and turn it round bodily until the line of sight coincides with the First Point of Aries on the wall. (It is as well to draw round the base of the measurer on the box and around the base of the box as well so that if it is moved, it can be put back in place again.)

When marking stars out on the wall, a good one to start with is Orionis. Leave the declination pointer at 0 (since this star is onthe equinoctial) and turn the upright part around until the index line points to 83° R.A. or 277° S.H.A. (both are the same). One child then looks along the sights while another places a star on the wall in line with them. ("Up a bit, down a bit, right -no - left - to me - to you,. etc.) This should be the smallest size of paper star in use as Orionis is almost third magnitude.

The next step is to put in, say, Betelgeuse (boys love this name, ugh!) and Rigel. Alnilam marks a point midway between them and the rest of the mighty hunter himself can be put in by eye with the help of a star map. Betelgeuse is of course 7° N of the equinoctial, so the pointer is set at that before the upright is swung round to read 88° R . A . or 272° S .H . A . The other stars are plotted in a like manner. Watch out for Rigel; it is south of the equinoctial:

You will find that this group of stars pretty well fills the end wall to the left of the first point of Aries and the next step is to choose a group to fill the other end wall. Stars with an S .H . A S.H.A. of about 90° or an R. A. of about 270° . The Scorpion and the Archer do very nicely (Scorpio and Sagittarius) and possibly the Eagle (Aquilla) too.

Now for the long wall opposite the First Point of Aries. The constellations hereabouts are rather thinner on the ground (so to speak) but the Lion and the Virgin will do very well, especially as they include the Northern Crown and the bright stars Spica and Regulus. Finally, the wall where it all started. The Great Square of Pegasus is the obvious one as well as Andromeda.

One can go on filling in the gaps until the walls glitter like the hosts of heaven themselves; Hercules , Perseus , the Swan and the Lyre, but before very long, the ceiling demands attention, the more so as some of the best known constellations should appear on it.

The Pole star, obviously at the very centre, immediately above the measurer. Steps and a plumb line or window pole, chewing gum and the well licked paper star will do the trick. The next step will be to put in Ursa Major, (the Plough, Charles' Wain or the Dipper according to taste) followed by Casssiopeia , Draco and Cepheus until the ceiling too is a joy to behold. It is when working with these high angle stars, that the reel of button thread comes in handy. Even though its inmates may not match the decor, the classroom has become a fair replica of the celestial sphere and the next step is to introduce a more mundane one, to whit, the earth itself.

The measurer is removed , together with the box on which it stands and the bicycle wheel orrery is put in its place with a large sheet of paper underneath. A little care is needed to check the points at which the rim is highest and lowest and to mark them on the stand. Similarly the two intermediate points at which it is exactly level with the centre of the hub. Standing at the low side and facing the wheel , it should revolve anticlockwise to carry the earth round in its proper orbit. If a torch battery and bulb be mounted with a piece of plasticine temporarily on top of the hub to represent the sun, it will be plain that when the earth is at its lowest point, the "sun" is well above its equator and even the north pole is bathed in light . (Blackout helps here.) Plainly this is the Northern Summer Solstice (June 21).

Turning the earth through its orbit (anti-clockwise) through 90 ("half-way up the slope"), it will have reached a position half-way between Summer and Winter , i .e . the Autumnal Equi- nox (September 21). Another 90 brings it to the highest point in the orbit and the "sun's" light will be shed on the southern half of the globe. If the torch bulb is just the right height, the "terminator" or edge of the shadow, will show the "midnight sun" at the Antarctic Circle and the shadow or "night" will just include the whole Arctic Circle. This obviously is the Northern Winter Solstice (December 1) . Another 90° takes the globe onto the Vernal Equinox, so that the shadow passes exactly through both poles and day and night are equally distributed. This point is the most important of all. Remove the bulb and battery, and stand behind the globe, sighting along from its axis to the hub of the wheel and thence to the wall beyond. Turn the whole orrery round on its base until you are sighting on the First Point of Aries (watch that the wheel does not spin while you do this, a wedge or a bit of paper stuffed under the spokes by the hub will stop it). An assistant with a plumb line can hang it close to the far side of the rim on the on the line of sight, and where it touches the paper underneath , a mark should be made and labelled with the sign for the First Point of Aries and the month March. The paper should be removed and marked out as shown in figure 5 before being replaced.

All is now ready fox' stargazing. Decide upon the date and place; say England in November at midnight. Remove the paper wedge so that the wheel turns freely and revolve it until the earth is over the month of November. Rotate the globe on its axis until England is on the far side from the hub, i.e. facing outwards. Now study the globe and the classroom walls; only those stars which are opposite the sun will be seen. Those on the "sun" side will not.

It is worth making a simple "horizon" of card which can be "stuck on England" (see figure 6). Anything "below" that horizon will be invisible. If the horizon has the points of the compass marked on it then the direction of the stars can be gauged. Similarly a little protractor and pointer can be made which will measure the altitude of stars above the horizon.

Another refinement is to make a circular dial of card to be stuck on the axis of the globe (see figure 6) showing the hours from 0 to 24 (anti-clockwise) and possibly a little cardboard pointer under the globe on the meridian of Greenwich so that it will tell Greenwich mean time . Other pointers could be made to say, India and America, if so desired. Thus children can set each other problems. Which constellations will be visible in January at 21 hours in England? Is a particular star visible? If so at what bearing and what altitude . The answer may be "Low in the South Western sky" or with more precision, "21° altitude bearing 220".

It is worth taking the trouble to mark out the ecliptic as being the path along which the sun appears to travel on an annual journey through the stars. This will, of course, be an extension of the plane of the bicycle wheel carried out to the classroom walls and, since it will be at an angle of 231° to the plane of the equinoctial, it will cut it at two points: the First Point of Aries and on the opposite side of the room at the First Point of Libra. The first points of all the other signs of the zodiac at 30 intervals can be marked on the ecliptic too . The month of the year can also be marked in a similar way be remembering that nowadays the first points are about the 21st day of each month or near enough 20° to the left of the first daX of each month. March would therefore extend from about 20 to the right of the First Point of Aries to about•10 to its left. A further exercise which may be worth pursuing with some of the more interested children would be to fix up a length of wire with a bead on one end and a loop on the other to fit over the top of the bicycle wheel hub bolt . If the wire is made the correct length, so that it is proportional to the radius of the wheel as the radius of the orbit of Mars is to that of the earth, the bead can be made to represent that planet. (142:93) If the bead representing Marscan be moved round in its orbit about 10° for every 25 moved by the earth, their relative motions will be approximately preserved. Sighting from the globe on the orrery, past the bead to the wall beyond, the apparent position of the planet can be registered on the wall (it is as well to get the R.A. of Mars for some given date from a current almanack as a starting point). All sorts of interesting things can come out of this exercise, including, if one adds in some intermediate points , the apparent retrograde motion of the planet. The strict proportion between the two years is of course, 365:686 and if one wanted to be more exact it would be possible to extract the right ascension and declination for Mars throughout the year from the almanack and plot its position on the wall. It would be interesting to compare the results so obtained with those obtained by using the bead and wire.

Another Aside

Here then lies the explanation of two lovely mouthfuls of words . "obliquity of the ecliptic" the angle between the ecliptic and the equinoctial. It has not always been the same. The earth , in spinning on its own axis, nods or "nutates" like a run-down top over the centuries and the obliquity of the ecliptic has sometimes been greater and sometimes less than at the present time.

Another interesting fact is that not only does the earth move round in its orbit, which is of course slightly elliptical and not circular like the bicycle wheel, but the orbit itself revolves slowly too. This can be shown by slowly rotating the the stand of the orrery. The First Point of Aries will move round with it. Hence the 20° between the first day of our present calendar months and the first point of the various houses of the zodiac.

The reason for the names of these signs of the zodiac will also come out of this little exercise, since, if the orrery be set to match the First Point of Aries with the first day of March , the houses will be found to coincide with the constellations along the new ecliptic line. Similarly calendrical changes over the centuries are explained.

This is obviously not a project for 40 children all working at once, still less is it one which can be completed in a week or two. There is probably all of a winter's work here, even if the children want to cover it all. Probably the best way to cover it all. Probably the best way to tackle it would be for children to work in twos and threes at various aspects, tackling the more mathematical side from time to time, perhaps painting, drawing and writing in between times. Perhaps a class might go only half way and get tired of it. Too bad. Their bits and pieces could however be put to one side and used with another lot next year, thus saving time and giving them a flying start.

It is not suggested that all the children's education could be extracted from such a project as this, nor indeed that other projects might not proceed in parallel, still less that the "hard teaching" of the more formal aspects of number and language are thereby rendered unnecessary: only that here is something children will enjoy doing, from which they will acquire some knowledge and much understanding and, as a result, will desire to acquire and improve their skills.

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Sizes: 4" x 3/4" or 5/8" hardwood

Base: 8" long

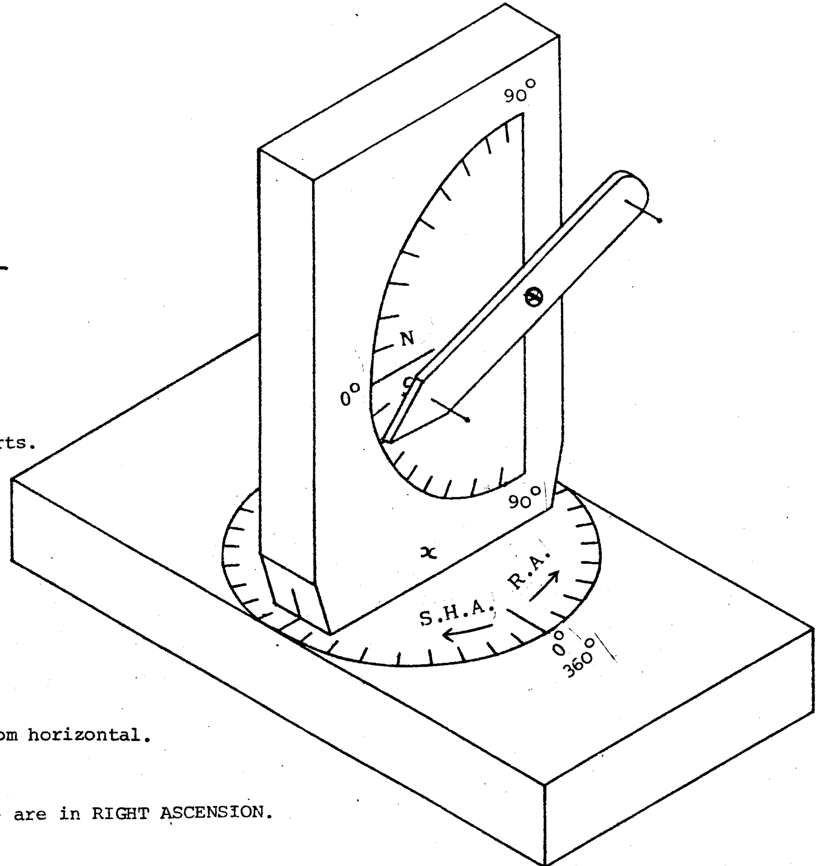
Upright: 6" - 8" high

x 1¾" No. 8 Brass screw up through easy-fitting hole in base (countersunk).

¾" No.6 Brass screw through easy fitting hole in pointer.

4" - 6" protractors (paper) on both parts.

Gauge line from screw centre for index on upright.



Note

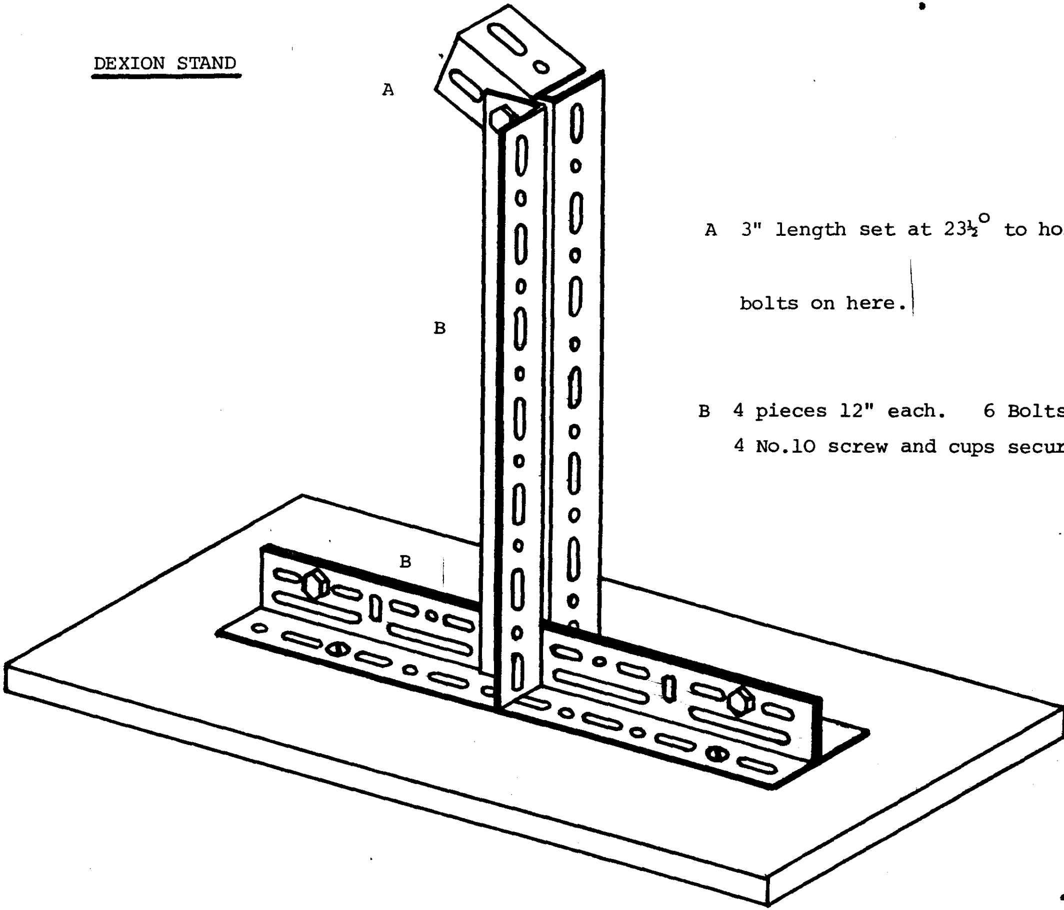
The vertical protraction is marked 0° - 90° from horizontal.

The horizontal protractor is marked 0° - 360°.

LEFT-HANDED if star positions in your catalogue are in RIGHT ASCENSION.
RIGHT-HANDED if given in SIDEREAL HOUR ANGLE.

Fig. 2

DEXION STAND



A 3" length set at $23\frac{1}{2}^{o}$ to horizontal;hub

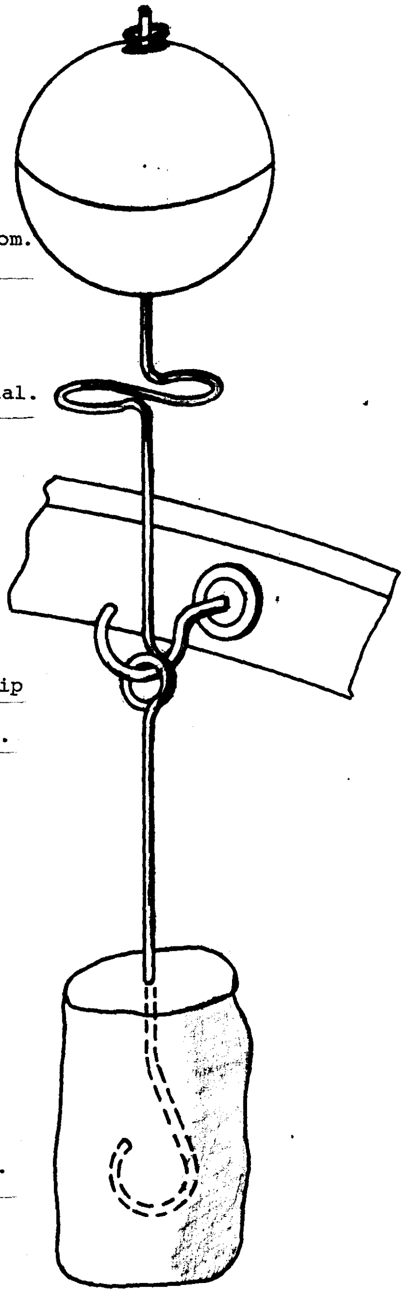
bolts on here.

B 4 pieces 12" each. 6 Bolts.

4 No.10 screw and cups secure to base board.

Fig. 3

GLOBE SUSPENSION



3" Toy globe.

Rubber band top and bottom.

Rest bracket for clock dial.

Rim of wheel, valve hole,

washer and cup-hook.

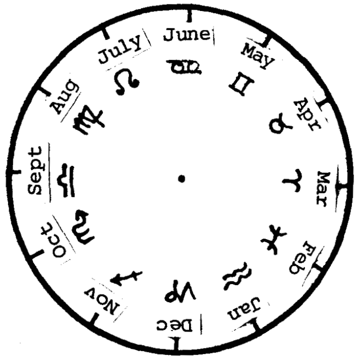
NB. You may need to shorten tip

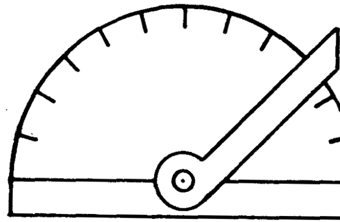
of cup-hook for clearance.

Plasticine balance-weight.

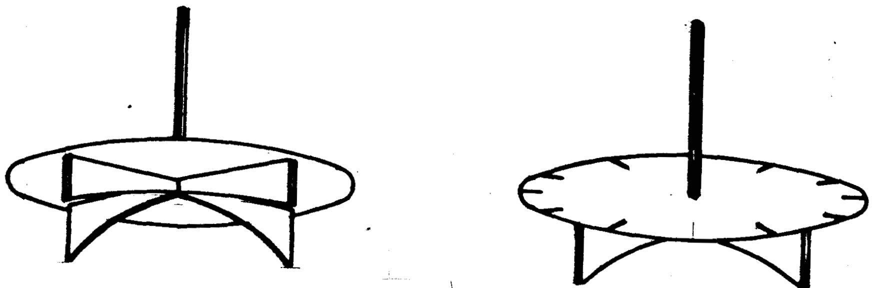
Fig. 4

THE FIRST POINTS OF THE HOUSES.





VERTICAL PROTRACTOR



HORIZON

(Radius of base = Radius of globe)

Match-stick as rest for vertical protractor.

Fig. 5

USE OF CARD HORIZON

Anything "below" horizon will be unseen.

All "above" will be visible.

The star shown is in the North-East altitude 60°.

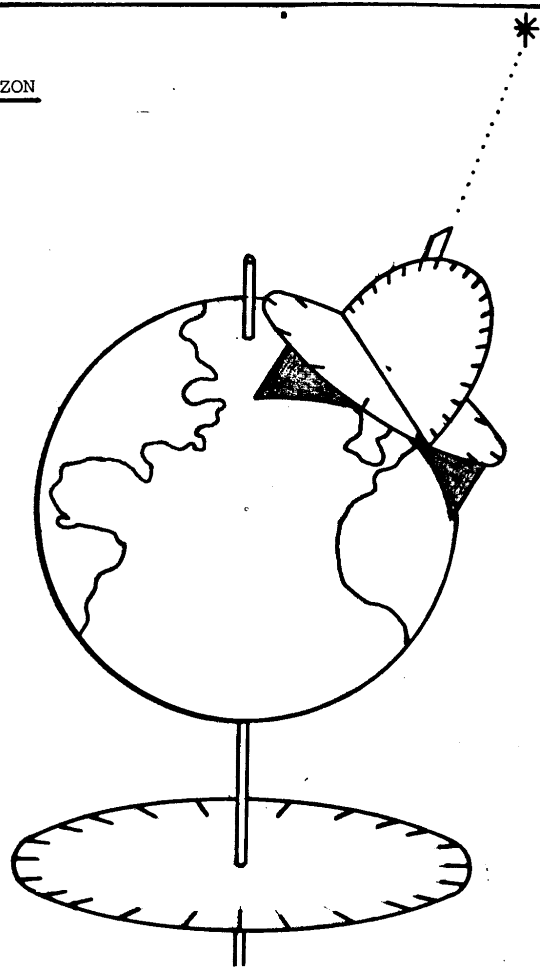


Fig. 6