

SECTION TWO: AIR-NAVIGATION STARS

Stars appear to gain on the Sun

19. The stars circle the earth in rather less than a whole day, so that a star which is due south of you to-night will be due south of you about four minutes sooner to-morrow night. In a month's time it will be there about two hours earlier. So that if a star-group is due south to-night at midnight, you will know roughly where to look for it at midnight in a month's time, because it will have been due south two hours before midnight. In a year's time it will be due south at midnight again.

Hourly Movement of Stars

20. The stars circle the earth very nearly once every twenty-four hours, though the circles all vary in size according to the position of the star. Consequently, if you note where a star is at a certain time, you will know roughly where to look for it in one hour's time—about a twenty-fourth of its way round the earth. It may help to understand the movement of stars if you take a ball to represent the heavens, mark it with a dot to represent a star and turn the ball slowly round.

21. A good practical way of telling what groups you can expect to see above the horizon at any time of night or year is to choose a master-group like the Plough which is always visible on a clear night to an observer in North Europe or North America, and remember how the other groups are placed in the sky relative to it. For instance, the Pegasus Square is on the opposite side of POLARIS to the Plough. If then you see the Plough to the right of POLARIS, you can expect to find Pegasus to the left of it, and so on. If the Plough is on the near side of POLARIS Pegasus will be on the far side, but it is far enough from POLARIS for it then to be below the horizon of an observer in North Europe.

Why The Plough never Sets for an Observer in North Europe

22. The Plough is so close to POLARIS that even when it is on the far side of POLARIS it is still above the horizon to an observer in North Europe.

What the Star Charts Show

23. The star charts show how the groups will appear at a particular time of the night and season. Owing to the apparent movement of the stars round the earth, the groups when seen may be spread out overhead, or perhaps may be in some other part of the sky and either on their side or upside down. Their shapes and dimensions, however, will always be the same.

STARS AND GROUPS FOR THE NORTHERN NAVIGATOR

The Plough (Charts 1 and 2)

24. The Plough, also known as the Great Bear and the Dipper, is the master group of the northern skies; the reasons for this are (i) for observers north of 40° N it never sets, (ii) it is the most

distinctive group of the northern hemisphere, and (iii) its two end stars provide the best pair of pointers to POLARIS.

25. The Plough is nearly overhead at midnight (not summer time) in March. The handle is then to the east of it.

It appears to revolve round POLARIS. It will therefore appear the other way up when on the far side of POLARIS and its handle will be to the left-hand side.

DUMHE, BENETNASCH

26. The important stars in the Plough are DUMHE, 2nd magnitude, No. 12, nearest of the group to the pole star and one of the two pointers to it; and BENETNASCH, 1st magnitude, No. 39, tail star of the handle; this is one of the stars used for the astrophot.

27. The Plough's greatest value to the air navigator is due to the pointers it provides. A line through the front two stars points close to POLARIS. Regarding the distance between the pointers as one length, POLARIS is about five lengths from DUMHE. (Star Chart No. 1.)

ARCTURUS, SPICA, Alphaacca

28. If the other end of the Plough, the handle, is produced in its natural curve, it leads to ARCTURUS, 1st magnitude, No. 7, the third brightest star in the northern heavens. ARCTURUS is about the same distance from the tail star of the Plough, as the pole star is from DUMHE. If the curve through ARCTURUS is continued for about the same distance again it leads to SPICA, 1st magnitude, No. 21 (Star Chart No. 2). A general line, uncurved, through the handle of the Plough leads in the direction of No. 26, Alphaacca, a 2nd magnitude star. It is about a third of the way from ARCTURUS to VEGA, a star in Chart No. 8. Alphaacca need not be learnt.

The Sickle or Reversed Question Mark (Chart 3)

REGULUS, Denebola

29. On the opposite side of the Plough to POLARIS and rather more than the same distance from the Plough is the Sickle or Reversed Question Mark. At the handle of the sickle or dot of the question mark is REGULUS, 1st magnitude, No. 17. It is slightly farther from POLARIS than ARCTURUS is. No. 30, Denebola, a 2nd magnitude star, lies nearly half-way between REGULUS and ARCTURUS. The Sickle and Denebola can be found by following a line from POLARIS through the body of the Plough. To an observer in Lat. 50° N the Sickle is only visible the whole night for a short period in the middle of February; but it is visible at some time during the hours of darkness from September to July. In September it is seen rising just before dawn and in July, setting just after dark.

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Square of Pegasus (Charts 4 and 5)

Cassiopeia, ALPHERATZ, *Hamel*

30. Cassiopeia is on the opposite side of POLARIS to the Plough and about the same distance from it. It contains no navigational stars but is an excellent sky-mark. It consists of five closely grouped but not very bright stars which resemble a straggly M when seen on the near side of the pole star and a W when seen on the far side of it. Like the Plough, it is visible the whole year round to a northern navigator.

On the opposite side of Cassiopeia to POLARIS and about as far is the Square of Pegasus with a handle similar to that of the Plough but concave to POLARIS.

Another point of resemblance to the Plough, and a good one, is that a line through the two end stars roughly points to POLARIS. It contains ALPHERATZ, 2nd magnitude, No. 4, at the junction of the square and the handle of the group. ALPHERATZ illustrates the importance of identifying stars by means of key groups; it is easily found as a member of the Pegasus group, but not otherwise because it is fainter even than POLARIS. Pegasus is visible the whole night from the middle of August to the end of September and is visible part of the night all the year except for a few days in March. No. 32, *Hewel*, a 2nd magnitude star, is on the opposite side of the Pegasus handle to Cassiopeia and about as far from it.

FOMALHAUT, *Dipha*

31. The two end stars of the Pegasus Square which point to POLARIS will, if produced the other way, point near FOMALHAUT, 1st magnitude, No. 13. FOMALHAUT is a long way from Pegasus, however, and, for an observer in Lat. 50° N, only just clears the southern horizon, though it is visible at some time during darkness from the middle of June to the end of January.

A curved line through ALPHERATZ and the fourth star of the Pegasus square will lead to *Dipha*, No. 31, a 2nd magnitude star.

Orion (Charts 6 and 7)

32. If the heavens are divided from pole to pole into four quarters and one quarter is allocated to the Plough, the opposite quarter will contain the Square of Pegasus. The quarter between the two on the 'handle'-of-Pegasus side will contain the great Orion.

Orion and the stars associated or grouped with it provides no less than seven out of the twenty-four air-navigation stars. Unmistakable, straddling the celestial equator with its four bright corners and belt of three with the 'sword', Orion is usually the first constellation learnt after leaving the cradle. It is never visible all night from Lat. 50° N, but can be seen at some time during the night from the middle of August to the middle of April.

BETELGEUSE, RIGEL, SIKRUS, ALDEBARAN, *Anlam*, *Amitak*, the Pleiades

33. When Orion is due south of the observer, RIGEL, 1st magnitude, No. 18, the brightest star

of the constellation, is at the bottom right-hand corner; BETELGEUSE, 1st magnitude, No. 8, is at the opposite, i.e., top left corner. At the top right-hand corner is No. 29, *Bellatrix*, a 1st magnitude star. The left-hand of the three belt stars is No. 25, *Amitak*, 1st magnitude; the middle star of the belt, No. 28, *Anlam*, also 1st magnitude.

If the belt is produced upwards in the direction of the Square of Pegasus, it leads to ALDEBARAN, 1st magnitude, No. 3, a popular star with navigators, which has a distinctive ruddy tint sometimes sufficient to identify it when no other stars are in sight.

Producing the line from the belt as far again beyond ALDEBARAN leads to a tight little group of stars, the Pleiades, which have no direct value except as a prominent, unmistakable sky-mark. They are about a third of the way between Orion and the Pegasus Square. Since ancient times they have been regarded as an eye-test—if you can see seven stars in the Pleiades from England on a clear night, you can take it that your sight is excellent.

If the belt is produced in the direction opposite to that of ALDEBARAN and about the same distance, it leads to SIKRUS, 1st magnitude, No. 20, the brightest star in the whole heavens. (Chart 6.)

PROCYON, POLLUX, Castor, CAPELLA, *Nak*, *Athena*, *Alphard*, *Wzen*, *Adara*

34. With centre a little north of Orion, a curve traced out through SIKRUS will pass through PROCYON, 1st magnitude, No. 16, POLLUX, 1st magnitude, No. 15, Castor, and CAPELLA, 1st magnitude, No. 10, in that order. Castor is not used for air navigation, but it is difficult to identify one of the twins Castor and POLLUX without knowing them both. CAPELLA is a valuable navigation star nearly in a line between Orion and POLARIS and about half-way. PROCYON, POLLUX, Castor and CAPELLA are often remembered by their first letters, P.P.C.C. No. 33, *Nak*, 1st magnitude, is a little more than half-way between *Bellatrix* and CAPELLA. No. 24, *Athena*, 1st magnitude, is not quite half-way between BETELGEUSE and POLLUX. No. 27, *Alphard*, 2nd magnitude is a comparatively feeble isolated star midway between Orion and SIKRA. Following a line from BETELGEUSE through SIKRUS along the edge of the Milky Way leads to No. 35, *Wzen*, 2nd magnitude, not far from SIKRUS; it is insignificant beside the mighty SIKRUS; close to it is No. 23, *Adara*, 1st magnitude. The Milky Way is a dense belt of distant stars encircling the heavens.

The Northern Cross or Swan (Chart 8)

VEGA, ALTAIR, DENEB, *Ras Alagaz*

35. In the fourth quarter of the heavens, to the Plough 'handle' side and between the Plough and Pegasus quarters, lies the Northern Cross.

It is on the opposite side of POLARIS to Orion. The ancients saw it as Cygnus, the Swan, with three stars representing the body and outstretched wings of a swan in flight; DENEB, 1st magnitude,

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No. 11, the brightest star, is the tail, and another star is the head at the end of a long outstretched neck.

On the ARCTURUS side of DENEB and a little more than a 'swan's length' away is the brightest star of the northern heavens, VEGA, 1st magnitude, No. 22. On the side of DENEB-VEGA, away from POLARIS, is another bright and important star, ALTAIR, 1st magnitude, No. 5. If DENEB, ALTAIR and VEGA are regarded as a large V, then VEGA is at the top of one arm of the V; if viewed as an A, then ALTAIR is at the top of the A. ALTAIR can be individually recognised by the pair of fainter stars, one on each side of it, the three being nearly in line with VEGA in the distance. The Northern Cross is visible all night from the middle of April to the end of August, and is visible at some time during the night the whole year round. No. 34, *Ras Alague*, is an insignificant 2nd magnitude star, not quite half-way between ALTAIR and ARCTURUS.

REVIEW OF THE NORTHERN NAVIGATOR'S STAR-GROUPS

36. This completes the list of stars in general use by the northern navigator operating in Northern Europe and North America. ANTARES, 1st magnitude, No. 6, in the Scorpion group (Chart 10), is never more than 14° above the horizon for an observer in 50° N—this occurs at the end of May—and half the Scorpion group does not rise above the horizon at all then; for that reason ANTARES is described with the southern navigator's stars.

The northern navigator's stars can be reviewed as follows:—

Wherever the Plough is, there also will be found ARCTURUS, SPICA and the Sickle; although, when the Plough is on the far side of POLARIS, these others will be below the horizon.

On the opposite side of POLARIS to the Plough is the straggly W of Cassiopeia, beyond that the Square of Pegasus, and beyond that again FOMALHAUT. When, therefore, the Plough is on the far side of POLARIS, look for Pegasus on the near side; when the Plough is to the right of POLARIS, Pegasus will be to the left, and so on.

In the third quarter of the heavens, between the Plough and the 'handle' of Pegasus, is the great Orion group. A line through the Belt of Orion finds SIRIUS and ALDEBARAN; Orion's corners farthest from the Belt are BETELGEUSE and RIGEL. Curving round Orion, from SIRIUS, a line will pass through P.P.C.C., PROCYON, POLLUX, CASTOR and CAPELLA. As Orion is in the quarter at the front of the Plough, only a glance at the Plough will be needed to decide whereabouts Orion is lying.

In that quarter to the 'handle' side of the Plough is the Northern Cross or Swan with DENEB its principal star, DENEB and two fine bright stars, VEGA and ALTAIR make a large V or A; if regarded as an A, then ALTAIR is at the top of the letter and if seen as a V, then VEGA is at the top of one of the sides of the letter.

 STARS FOR THE SOUTHERN NAVIGATOR
The Master Group

37. As with the northern stars, it will pay to remember how the southern stars are placed relative to a master-group; only a glance at the master-group will then be needed to tell which stars are visible in different parts of the sky at the time.

The Southern Cross (Chart 9)

38. The best known group in the south is the constellation of the Southern Cross. This is admirably suited to be the master-group; it is always above the horizon for an observer south of 35° S, and is the only conspicuous group which is 35° S is the approximate latitude of Sydney (33° 52' S), Auckland (36° 31' S), Buenos Aires (34° 37' S), and Cape Town (33° 54' S). Also the Cross provides the best and only conspicuous pair of pointers towards the south pole. These are the two stars forming its long axis. ('South pole' refers here to a point in the heavens vertically above the earth's south pole and marked with a small cross on the charts.)

If the distance between the two is thought of as a length, then the south pole is four-and-a-half lengths from the southernmost star of the Cross. Actually the pointers point 5° to the CANOPUS side of the pole.

ACRUX

The important navigation star of the Cross is the one nearest the south pole, ACRUX, 1st magnitude, No. 2.

The Centaurs. RIGEL KENT

39. More valuable to the sextant user are the pointers to the Cross, the Centaurs, of which the one furthest from the Cross is RIGEL KENT, 1st magnitude, No. 19.

The southern hemisphere has a poor lot of stars compared with the north; the Cross with the pointers to it and SPICA are the only important stars in the whole Southern Cross quarter of the southern heavens. However, an observer in Lat. 35° S will be able to see stars as far north as BENETNASCH which will just clear the northern horizon in April.

The South Pegasus Quarter

FOMALHAUT, ACHERNAR

40. On the opposite side of the south pole to the Southern Cross is the Pegasus quarter, but in the south of this quarter the only two important stars—both remarkable for their isolation in the heavens—are FOMALHAUT, already described and indicated by the pointers of the Pegasus Square, and ACHERNAR, 1st magnitude, No. 1. ACHERNAR lies half-way between FOMALHAUT and CANOPUS. The best way to identify it is by the combination of its brightness (it is the ninth brightest star of the heavens) and its isolation (the nearest bright stars to it are CANOPUS and FOMALHAUT, and these are both 40° from it—roughly the same distance

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as BENETNASCH from POLARIS). ACHEERNAR is always visible all night to the southern navigator. FOMALHAUT is only visible all night from the middle of August to the end of September, but always visible at some time of the night.

Northern stars of the Pegasus quarter which will be visible to an observer in Lat. 35° S, when the Southern Cross is on the far side of the South Pole include those of the Pegasus square and one of the three Pegasus-handle stars.

The South Orion Quarter (Chart 9)

Orion Stars. CANOPUS. The False Cross

41. The quarter on the opposite side of the Southern Cross to the pointers of the Cross is the South Orion quarter; and when the Cross is seen to the left of the south pole then the stars of the Orion quarter will be 'up'. To an observer in 35° S, looking north, SIRIUS will then appear not far from overhead. Orion will appear upside-down compared with a northerner's view of it, with REGUL at the top left-hand corner and BETELGEUSE at the opposite corner. ALDEBARAN will appear below Orion to the left, and CAPELLA will be just clearing the northern horizon. Orion is only visible all night for a few days in the middle of December but is visible sometime during the night throughout the year except for a few days in mid-June.

Looking towards the south pole when the Cross is to the left of it, CANOPUS, 1st magnitude, No. 9, the brightest star of the heavens after SIRIUS will be not far from overhead; it has a splendid whiteness and is one of the most easily identified stars. It is visible all night long from the middle of November to the beginning of March and is always visible sometime during the night. Between CANOPUS and the Cross lies the False Cross. Southern observers should become familiar with this at the first opportunity; it can easily be mistaken for the Southern Cross by anyone who does not know them both well. The sextant user could hardly be duped for long because shooting the False Cross instead of the Southern Cross would throw a position line nearly two thousand miles out, but an observer on the ground would seriously disorientate himself if he mistook the long axis for a pointer towards the south pole. It differs from the Southern Cross in that (a) it is nearly twice as large, (b) its stars are fainter, and (c) it lacks the brilliant pointer provided by the Centaurs.

The False Cross is visible all night from the middle of November to the middle of April and is always visible at some time during the night.

The Scorpion (Chart 10)

ANTARES. TRI AUST. PEACOCK

42. On the opposite side of the south pole to Orion, lies the Scorpion group which will be overhead for an observer in 35° S at the end of May at midnight or when the Southern Cross is to the right of the south pole. This is the largest group of

stars in the southern hemisphere. Probably most navigators see it as something different; for instance, it is as much like an attenuated Z as a scorpion, or a worn with its head down and tail up. In any case it shows up well and contains a conspicuous reddish star ANTARES, 1st magnitude, No. 6, easy to identify as soon as the Scorpion group is under observation. It is only visible all night for a day or two at the end of May, but is visible during some part of the night throughout the year except between mid-November and mid-December.

Between ANTARES and the south pole lies the Triangle, TRI AUST; three comparatively unimportant stars as far to one side of the Centaurs as the Southern Cross is to the other.

PEACOCK, 2nd magnitude, No. 14, as faint as POLARIS, is isolated about half-way between the Triangle and FOMALHAUT; or it can be described as lying between ACHEERNAR and ANTARES, or as forming a great equilateral triangle with ACHEERNAR and FOMALHAUT.

Looking north when the Southern Cross is to the right of the south pole, the southern navigator will see ALTAIR about half-way down the sky, with VEGA and the Northern Cross or Swan near the northern horizon. The Northern Cross is visible for some part of the night from the beginning of April to the end of October.

REVIEW OF THE SOUTHERN NAVIGATOR'S STAR-GROUPS

43. The Southern Cross makes an admirable master-group for the southern skies. Its long axis points close to the south pole. When it is on the near side of the south pole, the Plough is just below the horizon to the north, but SPICA, ARCTURUS and REGULUS will be visible.

When the Cross is on the far side of the pole, ACHEERNAR and FOMALHAUT are up and the Square of Pegasus will be visible near the northern horizon.

When the Cross is to the left of the south pole, CANOPUS and SIRIUS will be not far from overhead, with Orion and stars of the Orion quarter as far away as CAPELLA visible.

When the Cross is to the right of the south pole, the Scorpion has passed overhead and PEACOCK will soon be due south of the observer while between north and north-east, ALTAIR is high, VEGA and DENEB low, in the sky.

THE PLANETS

44. The planets are not of much use to anyone wanting to orientate himself without instruments or calculations because they are continually changing their positions relative to the fixed stars and each other; they must be known, however, so that there shall be no chance of mistaking them for stars.

Usually a planet can be distinguished from a star by its absence of twinkle; this is a safe enough rule for all practical purposes although sometimes in very clear atmosphere the stars, too, do not twinkle.

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Venus and Jupiter

45. There are many thousand 'wanderers' round the sun, but of these only four are of considerable use to the navigator; they are often far brighter than any star and therefore can be observed with a sextant before it is dark enough for the stars to show up, and sometimes before the sun has set.

Venus, the brightest, is nearer to the sun than the earth is. It closely accompanies the sun and is only visible when the latter is not far below the horizon. Therefore from the latitudes we are considering it is never visible more than three hours before sunrise or after sunset.

When the night is dark, except for starlight, Venus sometimes casts a perceptible shadow, and in a very clear sky it can sometimes be seen with the naked eye in broad daylight.

Jupiter is at times nearly as bright as Venus—though it varies—and in the same way, therefore, may have great value for the navigator in twilight.

Mars and Saturn

46. The next brightest planet to Jupiter is Mars, which, however, varies considerably. When at its brightest it is valuable to the air navigator, when it is faint, care must be taken not to mistake it for a star. It can usually be recognised by its ruddiness.

Saturn is sometimes fainter than Regulus, sometimes much brighter. The navigator who is constantly observing stars will keep an eye on the movement of planets so as to prevent any chance of mistaking them for stars.

ORIENTATION BY THE SUN

47. During the daytime you can orientate yourself by the sun; but not with the same accuracy as by the stars. First judge where due south (or north) is by the position of the sun. A rough method is to point the hour hand of a watch at the sun; south or north then lies about half-way between the hour hand and 12 o'clock (the watch must not be set to summer time); this method is not accurate but can be a great help if its limitations are known. For an observer in 50° N the worst error in telling the direction of south by this means will be 23° which can occur in midsummer; in September or March the error will not be more than 8°, and in midwinter not more than 5°.

If you make a practice of noting where the sun is at different times of the day you will be able to judge direction by it with surprising accuracy; try this.

THE MOON

48. It is possible to tell approximately when the moon will be visible at night by its shape. Its bright face is lighted by the sun and therefore roughly indicates its position relative to the sun. For instance, if the moon is full it is on the opposite side of the earth to the sun and will be visible all night. A half moon with its curved side to the east is about six hours ahead of the sun and therefore visible for about six hours before dawn. A quarter moon with its curved side towards the west is about three hours behind the sun and will be visible for about three hours after sunset.

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STARS, 1941, OCT.-DEC.

No.	Name	Mag.	S.H.A.	Dec.
1	ACHERNAR	0.6	336 07	S. 57 32
2	ACRUX	1.1	174 10	S. 62 46
3	ALDEBARAN	1.1	291 51	N. 16 24
4	ALPHERATZ	2.2	358 39	N. 28 46
5	ALTAIR	0.9	63 01	N. 8 43
6	ANTARES	1.2	113 33	S. 26 18
7	ARCTURUS	0.2	146 45	N. 19 29
8	BETELGEUSE	*0.8	271 50	N. 7 24
9	CANOPUS	-0.9	264 20	S. 52 40
10	CAPELLA	0.2	281 54	N. 45 56
11	DENER	1.3	50 08	N. 45 05
12	DUBHE	2.0	194 58	N. 62 04
13	FOMALHAUT	1.3	16 23	S. 29 56
14	PRACOCK	2.1	54 44	S. 56 35
15	POLLUX	1.2	244 34	N. 28 10
16	PROCVON	0.5	245 56	N. 5 22
17	REGULUS	1.3	208 41	N. 12 15
18	RIGEL	0.3	282 04	S. 8 16
19	RIGEL KENT	0.1	141 06	S. 60 36
20	SIRIUS	-1.6	259 21	S. 16 38
21	SPICA	1.2	159 28	S. 10 51
22	VEGA	0.1	81 16	N. 38 44
23	Adara	1.6	255 55	S. 28 54
24	Alhena	1.9	261 25	N. 16 27
25	Alnitak	1.9	275 32	S. 1 58
26	Alphacca	2.3	126 57	N. 26 55
27	Alphard	2.2	218 49	S. 8 24
28	Anilam	1.8	276 41	S. 1 14
29	Bellatrix	1.7	279 30	N. 6 18
30	Denebola	2.2	183 29	N. 14 54
31	Diphda	2.2	349 50	S. 18 18
32	Hamal	2.2	329 01	N. 23 11
33	Nath	1.8	279 21	N. 28 33
34	Ras Alhague	2.1	96 57	N. 12 36
35	Wezen	2.0	253 29	S. 26 18
39	BENETNASCH	1.9	153 42	N. 49 36
47	POLARIS	2.1	333 45	N. 88 59

* BETELGEUSE variable magnitude—0.5—1.1.

Table of the stars described in these notes, taken from the Air Almanac, 1941.

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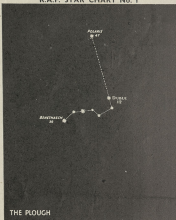
The Celestial Clock

The apparent motion of the heavens, due to the daily rotation of the earth on its axis and the yearly motion of the earth round the sun, can be understood easily if we think of the heavens as a clock. POLARIS is the centre of the face, and the

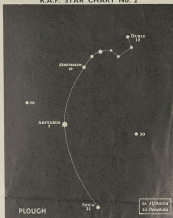
line joining it to the Pointers of the Plough is the hour hand. This hand goes round once in 23 hours, 56 minutes, 4 seconds, in a counter-clockwise direction. With the pointer goes the whole clock face.

The yearly movement causes the celestial clock to gain a couple of hours per month.

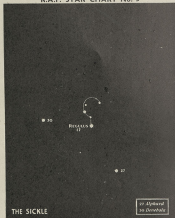
R.A.F. STAR CHART No. 1



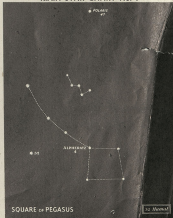
R.A.F. STAR CHART No. 2



R.A.F. STAR CHART No. 3



R.A.F. STAR CHART No. 4



NOTES FOR INSTRUCTORS AND STUDENTS

