It would, according to this registry, be produced by 417 *complete vibrations per second*.

In the time of Louis XIV., the pitch of this A was, according to Sauveur, 405 vibrations per second, while by the action of the Congress called together by the Society of Arts, at London, in 1860, it was 440. The same note sounded by Handel's tuning-fork (1740) is said to have been made by 416 vibrations per second. It will thus be seen, that while the present pitch is nearly one-half of a tone higher than that referred to by Sauveur, and considerably more than that interval lower than that of the London Congress, it agrees with the pitch adopted by Handel to within a single vibration.

EASY RULES FOR ASTRONOMICAL REFRACTION.

BY BENJAMIN SMITH LYMAN.

IN using the solar compass, as well as other astronomical instruments, the refraction of the atmosphere must be taken into account as changing the apparent place of the sun or other heavenly body. In the zenith, the apparent place of such a body is not affected by refraction, but everywhere else it is raised above the true place; little near the zenith, but more and more towards the horizon, and some thirty-five minutes at the horizon. The amount of displacement changes too with changes in the weight and heat of the air, as shown by the barometer and thermometer. Near the horizon the refraction is great and changes very fast with a small change of the true height or altitude; and as the rays of light then pass for a greater distance through the air, and through much of it quite near to the earth's surface, they are greatly exposed to change from variations along their path in the weight and heat of the air, variations that clearly must be quite unknown. Hence, astronomers say that no table of refraction can be depended on within five degrees of the horizon, although tables are given all the way from the zenith down to the horizon.

It is customary to calculate the refraction for any given height of a heavenly body, and for any state of the air, by means of these tables and by complicated formulas. But for the solar compass, which has no means of marking the refraction nearer than to full minutes, and, indeed, for sextants or other instruments that do not read closer than to five seconds, two or three very simple rules are as good as the tables for all heights above three degrees and

a-half; and observations should not be made lower than that, at any rate. These rules are very easy to remember, and by them the refraction can readily be calculated in the head.

The first rule is for the mean refraction—that is, the refraction when the barometer is at thirty inches and the thermometer at fifty degrees, Fahrenheit. *Add one degree and three-quarters ($1^{\circ} 45'$) to the true altitude, and divide sixty-eight degrees (68°) by the sum; take one-half ($\frac{1}{2}$) from the quotient, and the remainder will be the number of minutes of mean refraction.* For example, to find the refraction for a true altitude of seven degrees and fifty-eight minutes:

$$\frac{68^{\circ}}{7^{\circ} 58' + 1^{\circ} 45'} - \frac{1}{2} = \frac{68^{\circ}}{9^{\circ} 43'} - \frac{1}{2} = 7 - \frac{1}{2} = 6\frac{1}{2};$$

and the refraction is six minutes and a-half, exactly as given in the table of refraction in *Chauvenet's Astronomy* (1863). With an instrument, like the solar compass, that marks the refraction only to the nearest full minute, the whole number of the quotient will simply be taken as the refraction: as seven in the example just given. For plainly any quotient between seven and eight would answer to a refraction between six and a-half and seven and a-half—that is, in round numbers to seven.

The following table, chiefly for every odd half minute of refraction, shows the altitudes down to two degrees, for which these amounts of refraction are calculated by the rule, and the refraction for the same altitudes by the tables, and the difference between the two, or the error of the rule.

It is clear, that for any altitude above two degrees and a-half, the rule is quite exact enough for any instrument that does not read closer than half minutes, and from three degrees and a-half up to sixty degrees for any instrument that reads only to five seconds.

The second rule is for instruments that read to five seconds. *The mean refraction between the zenith and fifty-seven degrees (57°) altitude is eleven tenths of a second ($1.''1$) for every degree of distance from the zenith.* For example, the refraction at 75° of altitude is, by this rule $16.''5$, or only one second more than is given in the tables, and this is the greatest error of the rule anywhere above 59° , and at 57° the error is only $1.''5$.

The third rule is for the allowance to be made for changes of the barometer and thermometer, and is simply: *Add to the mean refraction at the rate of doubling for a rise of thirty inches in the barometer, or for a fall of five hundred degrees in the thermometer.* The refrac-

tion should, of course, be lessened at the same rate for a fall of the barometer or rise of the thermometer. For example, when the barometer is at 31·5 inches, and the thermometer at 75°, the mean refraction of ten minutes becomes $10 + \frac{1}{30} \times 1\cdot5 - \frac{1}{30} \times 25 = 10 + 0\cdot5 - 0\cdot5 = 10$; that is, it is unchanged. The rule is exact for the

TABLE I.

True Altitude.	Refraction.		Error of Rule.
	By Rule.	By Table.	
90° 0	0' 14''·4	0' 0''·0	+ 14''·4
68 0	0 28·5	0 23·6	+ 4·9
66 15	0 30·0	0 25·6	+ 4·4
60 0	0 36·0	0 33·6	+ 2·4
57 0	0 39·6	0 37·8	+ 1·8
32 15	1 30·0	1 32·0	— 2·0
20 55	2 30·0	2 31·0	— 1·0
15 15	3 30·0	3 29·7	+ 0·3
11 51	4 30·0	4 29·2	+ 0·8
9 35	5 30·0	5 29·3	+ 0·7
7 58	6 30·0	6 30·0	0·0
6 45	7 30·0	7 31·0	— 1·0
5 48	8 30·0	8 29·9	+ 0·1
5 3	9 30·0	9 32·3	— 2·3
4 26	10 30·0	10 31·0	— 1·0
3 55	11 30·0	11 29·5	+ 0·5
3 29	12 30·0	12 28·5	+ 1·5
3 6	13 30·0	13 27·2	+ 2·8
2 47	14 30·0	14 40	— 10
2 30	15 30·0	15 19	— 11
2 15	16 30·0	16 9	— 21
2 2	17 30·0	16 58	— 32

barometer, and agrees with Chauvenet's tables, between fifty and a hundred degrees of the thermometer, but gives slightly too little refraction for a low state of the thermometer. This error, however, at ten degrees below zero is, according to Chauvenet's tables, only eighteen seconds for a mean refraction of ten minutes; and according to the tables given in *Norton's Astronomy*, is only eleven seconds. At zero, the error for the same mean refraction would be only fourteen seconds, by Chauvenet's tables. This rule, then, is

quite exact enough for any instrument that does not read closer than half minutes, and with all ordinary weather and altitudes, even for instruments that read to five seconds.

The following table gives the true and apparent altitudes down to five degrees for every odd half minute of mean refraction—that is, the altitudes at which the amount of refraction changes from one minute to the next, when only full minutes are taken account of, as in the solar compass.

TABLE II.

Altitude.		Refraction.	
True.	Apparent.	Exact.	Nearest Minute.
90° 0'	90° 0'	0' 0''	
62 46	62 46	0 30	0
32 40	32 42	1 30	1
21 3	21 5	2 30	2
15 14	15 17	3 30	3
11 49	11 53	4 30	4
9 34	9 39	5 30	5
7 58	8 4	6 30	6
6 46	6 54	7 30	7
5 50	5 58	8 30	8
5 5	5 14	9 30	9
4 27	4 38	10 30	10

The foregoing tables have been made from the tables in *Chauvenet's Astronomy*, with the help, also, of the older ones given in *Norton's Astronomy* (edition of 1867).

135 South Fifth Street, Philadelphia.

10th September, 1869.

ON VARIOUS PROCESSES FOR PRESERVING TIMBER.

By DR. ADOLPH OTT.

(Concluded from page 248.)

On the properties of resinous timber, and the unchangeability of resinous substances in general.

AMONG the various woods which are used either in house, ship-building, or other purposes, we meet some which, though even when not operated upon by chemical agencies, are renowned for their