448 Vitis or Cissus, fr. Nipal.

Sp. 4·5 inch. diam.; wood spongy and very coarse-grained; fibre very small in proportion to the tubes, which are many and large; rays very distinct, of a reddish brown colour, forming a handsome waved figure; bark stringy.

449 Wrightia gigantea, *Wall.* fr. Nipal.

A large climber.—Sp. 2·5 inch. diam.; 10 layers; wood whitish, with considerable lustre; rather soft.

450 Wrightia antidysenterica. Lathon, B. fr. Tavoy.

A small tree; not used.

451 Wrightia tinctoria. (Indigo tree.)

The leaves yield indigo. The wood is "beautifully white, close-grained, coming nearer to ivory than any other known to me."—*Roxb.*

452 Xanthophyllum. Saphew, B.; Choo-muna, T.; fr. Martaban.

Very large; wood used for posts and rafters.

453 Xanthoxylon alatum. Timbhus, P. and N. fr. Nipal.

Wood soft and open-grained, like aspen; bark very tubercular.

454 Xylocarpus. Keannan, B. fr. Tavoy.

Timber from 10 to 20 feet long; very durable; used for furniture and in house-building.

Zeethee. See Ziziphus.

Zimboon. See Dillenia.

Zitha. See Castanea.

455 Ziziphus incurva. Harobaer, P.; Kadabusi, N.; fr. Nipal.

Wood in considerable estimation.—Sp. 3·5 inch. diam.; fibre brownish white, with little lustre; rays in the outer layers distinct, but of the same colour as the fibre; bark coarsely fibrous.

456 Ziziphus. Zeethee, B. fr. Tavoy.

Wood hard and durable.

III.—*Table for ascertaining the Heights of Mountains from the Boiling Point of water.* *By* James Prinsep, *Sec., &c.*

A correspondent has suggested to me that many readers of the Journal are anxious to possess a ready means of measuring heights by the temperature of boiling water, as it frequently happens that they find themselves in situations where this simple method may be applicable when it is out of their power to resort to the more generally practised operation with a barometer.

I have accordingly drawn out a table founded on the best procurable data of the present time: but it must not be concealed that sufficient accuracy has not been attained in experimental researches on steam of low temperatures to warrant implicit reliance upon the results; for although, since the important application of steam as a motive power, numerous experiments have been made to ascertain the *elastic tension* which it exerts at different temperatures both below and above the ordinary boiling point; still, *below* 212°, the points fixed by experiment are at intervals of several degrees asunder, and there is no thorough accordance between those of different experimenters.

Perhaps it is necessary to explain, that the boiling point is that degree of heat at which the elastic force of aqueous vapour is just capable of counterpoising the pressure of the atmosphere, or the weight of the column of mercury in a barometer. The method then of discovering the law of progression of the tensions has generally had for its basis the exposure to heat of a portion of water in a closed vessel, such as a glass tube or a small boiler, under the pressure of a column of mercury, measuring the height to which the latter is raised at different temperatures.

Betancourt, Schmidt, Dalton, Watt, Creighton, Southern, Taylor, and more recently Ure, Arsberger, Perkins, and Dulong (assisted by a commission of the French Academie), are some of the illustrious names which are connected with these researches experimentally; while Robison, Young, Ivory, Laplace, Prony, Tredgold, Coriolis, Laroche and others have attempted to construct mathematical formulæ, capable of embracing the range of their experiments from the freezing point up to 500° Farh.* It is quite unnecessary for me to enter into any lengthened history of this branch of physics, which the reader will find ably discussed in *Robison's Mech. Phil., Biot, Tredgold on the Steam Engine, Daniell's Meteorology*, and in the report of Dulong to the Academie on *the experiments made by order of the French Government to determine the elastic force of aqueous vapour at high temperatures.* [*An. Chim.* xliii.]

All the experiments agree in proving the elastic force of steam to follow a geometrical ratio with arithmetical increments of heat. The index of the power representing the law of variation was assumed as 5.13 by Southern, 6 by Creighton, 7 by Young, by Coriolis 5,355, and by Dulong 5. But the formula of Tredgold is acknowledged to agree more closely with experiments below 300° than any other:—his exponent is also 6, with a different co-efficient; if f = elastic force, and t temperature, then by his formula

$$f = \left(\frac{t + 100}{177}\right)^6 \text{; or } t = 177 f^{\frac{1}{6}} - 100$$

in logarithms

$$\log. f = 6\,(\log.\,(t + 100) - 2.247968)$$

* The experiments of the French Academicians Baron de Prony, Arago, Gerard and Dulong, in 1829, extend to the temperature of 435° Fahrenheit, or a pressure of 24 atmospheres, which they measured by absolute pressure of a column of mercury *sixty feet high* in a glass tube attached to the tower of the Old Church of Sainte Geneviéve:—they were afraid of passing this limit, as the least explosion would have brought down the tottering fabric. Their glass tube was jointed and ingeniously supported: Mr. Daniell has however since worked with *single* glass tubes of 40 feet long, in his water barometer experiments. We deal now-a-days boldly with feet, where inches were formerly thought sufficient!

With this formula I had constructed a table from 214° to 180°, when I perceived that the calculated pressures gradually gained upon the experimental ones within the same range, until at 180°, the difference was a full third of an inch. This will be seen in the diagram of Plate VIII, and in the following comparative table :

Temperature	Calculated Tension by Tredgold's formula	Observed Tension	Differences	Observer
°	in.	in.		
212	30.00	30.00	0	assumed
210	28.86	28.88	+.02	Ure
210	28.86	28.82	—.04	Robison
202	24.68	24.37	—.31	Wollaston
200.75	24.07	24,00	—.07	Dalton
200	23.71	23.60	—.11	Ure
200	23.71	22.86	—.85	Robison
190	19.35	19.00	—.35	Ure
189.5	19.15	18.80	—.35	Dalton
182	16.35	16.01	—.34	Southern
180	15.67	15.16	—.51	Ure
180	15.67	14.73 ?	—.94	Watt
178.25	15.10	14.60	—.50	Dalton
173	13.46	13.18	—.28	Dalton
172	13.17	12.72	—.45	Southern

ROBISON's numbers are much too low : the others, DALTON's, SOUTHERN's, and URE's, agree pretty well together, gradually separating from the curve of TREDGOLD's formula. On the supposition that the experimental results, when they evince so much regularity, are more trustworthy than the calculus, (which is indeed empirically formed to suit them), I have made a deduction of [0.01 inch × number of degrees below 212], from the numbers in TREDGOLD's column, and then I find that the experimental and theoretical curves coincide very well throughout the range required for our purpose.

The extreme difference at 180° will thus amount to

	inches.		
log. of	15,67	=	1.19511
log. of	15,31	=	1.18611
			.00900

=90 fathoms or 540 feet, a quantity of too much magnitude to be passed over.

Having thus explained the construction of the following Table, I will proceed to make a few remarks on the mode of using the instrument to which it applies.

The Rev. F. J. H. Wollaston was the first to introduce the thermometer practically as a substitute for the barometer in measuring heights. His plan was merely to render the thermometer more delicate by increasing the bulb, and allowing the mercury to enter the capillary tube only when it approached the boiling point, so that a few degrees occupied the whole scale, and by a sliding nonius each degree could be divided into 200 parts or more. But it is evident that to compete with the barometer in *accuracy of indications*, the scale must have a range of the same length as that of the barometer,—say 15 inches, and the instrument would thus become fragile and unwieldy: to obviate this inconvenience, he formed a reservoir above the capillary tube, containing a small supply of mercury, so that when the boiling temperature should be so reduced as to bring the reading point to the foot of his 6-inch scale, a portion of mercury was to be added to bring it to the top of the scale, by an operation so delicate and difficult that I may safely say, and from experience too, that few travellers would resort to it in the field, and fewer still succeed if they attempted it. In 1817, he exhibited his thermometer to the Royal Society, and in 1820, he applied it to the measurement of Snowdon. On the latter occasion, he drew up a table of the value of the degrees between 214° and 202° in feet, founded on Doctor Ure's empirical formula of tensions; but, as this range only extends to an altitude of 5405 feet, it is evidently quite insufficient for the traveller in India, who may ascend to 18,000 feet and still see *Snowdons* towering above his head.

The error into which Wollaston fell was an attempt at too great sensibility. His instrument is beautiful in a laboratory, where it will serve to shew minute variations in the index error, as it may be called, of a barometer in the course of years, as I have frequently proved. But for rough work out of doors, accuracy must in some measure be sacrificed to strength and portability, the points in which alone the thermometer can boast superiority over the barometer. Captain Herbert was so well aware of this, that he had provided himself from England with ordinary thermometers divided, from 180° upwards, to the tenths of degrees: half a division thus represented about 25 feet, which in most cases was ample, especially when the zero of elevation, or level of the sea, was 1000 miles distant.

All who possess thermometers, therefore, divided to tenths of inches, may convert them into measurers of height, by attending only to a few trifling precautions in their use.

1. The *prime* boiling point 212° should be accurately verified by comparison with a good barometer, for the divisions of the instrument-makers are by no means to be trusted within the requisite limits. Thus,

on some standard thermometers in the Surveyor General's office, in our experiments on the standard bar, we found the boiling point erroneous *two degrees:* and Lieut. Burnes found his thermometer boil on the Caspian Sea at 213°½ which would make its surface 700 feet below the level of the Mediterranean, whereas it is only suspected of half that depression.

2. The metal or wooden scale should be cut off at some height above the bulb, as otherwise it is very difficult to obtain the temperature correctly, or even to attain full ebullition, on account of the rapid abstraction of heat by the scale, particularly if it be of metal.

3. The vessel in which the water is boiled should be of metal, closed loosely with a cover or cork through which the thermometer may pass, so that the bulb may remain a trifle above the surface of the water. To those who cannot provide themselves with a boiler similar to that of Wollaston, a shaving pot will be found to answer sufficiently well. The steam should issue freely through the vent for some time before the reading is taken.

A word or two, now, on the mode of applying the following table to the calculation of the height required.

1. When the thermometer has been boiled at the foot and at the summit of a mountain, nothing more is necessary than to deduct the number in the column of feet opposite the boiling point below, from the same of the boiling point above:—this gives an approximate height, to be multiplied by the number opposite the mean temperature of the air in Table II. for the correct altitude.

		°		feet.
Example.	Boiling point at upper station	201.5	=	5600
	Ditto ——— at lower station	211.3	=	350
			Approximate height,	5250

Temperature of air, above, 35°
below, 50

Mean 42,5 = multiplier,................ 1.022

Correct altitude, ...ft. 5365.5

2. When the boiling point at the upper station alone is observed, and for the lower the level of the sea or the register of a distant barometer is taken, then the barometrical reading had better be converted into feet by the usual method of substracting its logarithm from 1,47712 (log. of 30 inches) and multiplying by .0006, as the differences in the column of "barometer" vary more rapidly than those in the "feet" column.

feet.

Example. Boiling point at upper station .. .. 185° = 14548

Barom. at Calcutta (at 32°) 29.75

Logar. diff. = 1.47712— 1.47349 = ,00363 ×.0006 = 218

Approximate height 14330

Temperature, upper station, 76° } 80 = multiplier 1.100
Calcutta, .. 84 }

Correct altitude, ft. 15763

3. Assuming 30.00 inches as the average height of the barometer at the level of the sea (which is however too much), the altitude of the upper station is at once obtained by inspection of table I, correcting for temperature of the stratum of air traversed, by table II.

TABLE I.—*To find the Barometrical Pressure and Elevation corresponding to any observed temperature of boiling water between* 214° *and* 180°.

Boiling point of water.	Barometer (modified from Tredgold's formula.)	Logarithmic differences (or fathoms).	Total Altitude from 30.00 in. or the level of the Sea.	Value of each degree in feet of Altitude.	Proportional part for one-tenth of a degree.
°	inches.		feet.	feet.	feet.
214	31.19		—1013		
213	30.59	.00 84,3	— 507	—505	
212	30.00	84,5	0	—507	
211	29.42	84,9	+ 509	+509	
210	28.85	85,2	1021	511	51
209	28.29	85,5	1534	513	
208	27.73	85,8	2049	515	
207	27.18	86,2	2566	517	
206	26.64	86,6	3085	519	52
205	26.11	87,1	3607	522	
204	25.59	87,5	4131	524	
203	25.08	87,8	4657	526	
202	24.58	88,1	5185	528	
201	24.08	88,5	5716	531	53
200	23.59	88,9	6250	533	
199	23.11	89,3	6786	536	
198	22.64	89,7	7324	538	
197	22.17	90,1	7864	541	54
196	21.71	90,5	8407	543	
195	21.26	91,0	8953	546	
194	20.82	91,4	9502	548	
193	20.39	91,8	10053	551	55
192	19.96	92,2	10606	553	
191	19.54	92,6	11161	556	
190	19.13	93,0	11719	558	
189	18.72	93,4	12280	560	56
188	18.32	93,8	12843	563	
187	17.93	94,2	13408	565	
186	17.54	94,8	13977	569	57
185	17.16	95,3	14548	572	
184	16.79	95,9	15124	575	
183	16.42	96,4	15702	578	58
182	16.06	96,9	16284	581	
181	15.70	97,4	16868	584	
180	15.35	97,9	17455	587	59

The fourth column gives the heights in feet.

Table II, *of Multipliers to correct the approximated Height for the Temperature of the Air.*

Temp. of Air.	Multiplier.	Temp. of Air.	Multiplier.	Temp. of Air.	Multiplier.
°		°		°	
32	1,000	52	1,042	72	1,083
33	1,002	53	1,044	73	1,085
34	1,004	54	1,046	74	1,087
35	1,006	55	1,048	75	1,089
36	1,008	56	1,050	76	1,091
37	1,010	57	1,052	77	1,094
38	1,012	58	1,054	78	1,096
39	1,015	59	1,056	79	1,098
40	1,017	60	1,058	80	1,100
41	1,019	61	1,060	81	1,102
42	1,021	62	1,062	82	1,104
43	1,023	63	1,064	83	1,106
44	1,025	64	1,066	84	1,108
45	1,027	65	1,069	85	1,110
46	1,029	66	1,071	86	1,112
47	1,031	67	1,073	87	1,114
48	1,033	68	1,075	88	1,116
49	1,035	69	1,077	99	1,118
50	1,037	70	1,079	90	1,121
51	1,039	71	1,081	91	1,123

Enter with the mean temperature of the stratum of air traversed; and multiply the approximate height by the number opposite, for the true altitude.

The table of Tensions (tab. I.) is still avowedly imperfect. We see that the force of vapour for 210°, as found by observation, differs several hundredths of an inch from the formula of either Dalton, Ure, or Tredgold, although only two degrees distant from the fixed point 212°. Nor can it surprise us to find it so, because its experimental determination, by heating vapour inclosed within the thick glass of a barometer tube, is necessarily subject to much more uncertainty than the obvious measurement of the boiling point, under a given pressure of the air. On the mountains of India, at Simla, Súbaṭhú, Chirra Púnjí, and even *Spití*, wherever in short there may be observers in possession of good barometers, the power exists of rendering an essential service to physics by fixing so many points on the scale of tensions, in the latter more unexceptionable manner. For instance, an observer at Chirra, by carefully noting the heat of his boiling tea-kettle every morning, and inserting it in his register, together with the accurate height of the barometer, would determine that part of the thermometric scale corresponding to 25 and 26 inches of pressure. So with observations at Ságur, for 28 inches; at the Nilgherries for 21 inches; and in the Himálaya for even 15 inches: and I hope that this notice may have the effect of inducing this new and interesting species of *synthetical* research, as a check upon the scales framed on an opposite system in the laboratory.