set aside in this way to maintain a close liaison with the Department of Mathematics, which, it is anticipated, will occupy the greater part of this floor for some years to the mutual benefit of both subjects. On this floor a room 53½ by 26 feet, with a gallery, is allotted to the library, and will provide accommodation for many years for the growing needs of the two departments in this direction.

An important bequest by Mr. John Exley to the University College of Bristol in 1900 has provided the library with valuable sets of back numbers of leading scientific periodicals. The supply of these has since been maintained by annual grants which will be supplemented, owing to Council's decision to allocate to the Physics Library the income from a capital sum of about £1800 bequeathed to the University by Miss Maria Mercer.

The short arm of the "L" contains two storeys, and includes two theatres, apparatus rooms, and cloak rooms. The larger theatre, on the first floor, contains seating for 300 as a minimum, but bench seats provide for a considerably larger audience on special occasions. Its blinds are electrically controlled. The smaller theatre is beneath it, and is provided with a minimum seating of 130. The acoustic properties of both theatres have received particular consideration.

Under the roof of each arm of the building there is a large loft suitable for extensive storage or, if need be, for any special experiment requiring an uninterrupted length of space.

The junction of the two arms of the building is surmounted by a tower 64 feet square. In this there is a fourth floor containing two large rooms available for research. It is flanked by four turrets, one of which contains a vertical shaft, 4 feet by 3 feet, which goes to the bottom of the building, 90 feet below.

In the general equipment of the rooms special regard has been paid to the wishes of the donor that the furniture and fittings should be of such a high quality as would relieve the University from expenses of repairs for many years to come. The changing needs of any scientific laboratory in these days of rapid advance have, however, been constantly kept in mind, and nothing has been done to diminish the flexibility of the equipment essential to meet new conditions as required. In the provision of gas, water, and electricity in the various rooms the rival claims of the overhead system and the floorduct system have been carefully considered. It was felt that in the main teaching laboratories, where the presence of a few fixed tables distributed over the floor has no inconvenience, the floorduct system has fewer disadvantages, and for this reason it has been adopted. In the research rooms, many of which are relatively small, the supplies of gas, water, and alternating current are conveyed through the rooms in floorducts, and those of direct current of various voltages by bare wires overhead. At the same time, a horizontal duct with creeping way is provided in the roof of the main corridors. This not only serves the purpose of a vitiated air duct in the ventilation system, but also gives means for rapidly laying any temporary cable or piping as required to any room.

For the supply of compressed air and of vacuum, the unit system has been preferred to that of general distribution. Any worker who requires either of them has it thus under his own control.

The University Council has been fully alive to the necessity for funds for apparatus and for additional personnel. It has, however, aimed at avoiding the mistake of installing special equipment of a costly character before men are available to use it, and equally that of creating a number of new posts before funds are available for the provision of the apparatus necessary for their investigations. In apparatus, therefore, immediate provision has been made for the researches of the existing staff, and for the present requirements in teaching, while a small reserve fund has been set aside to form a nucleus for future needs.

In the provision of personnel the Council has found its way to meet some of the new requirements by the creation of certain new posts. Thus, as has been already announced in these columns, Dr. J. E. Lennard-Jones has been appointed to a professorship in theoretical physics and Dr. L. C. Jackson and Dr. H. W. B. Skinner to Henry Herbert Wills' research fellowships.

If, however, the laboratory is to be put to the full uses that its donor desired, further additions to the personnel and equipment will be necessary, and it is hoped that both will soon be forthcoming.

The Velocity of Light.

By M. E. J. CHEURY DE BRAY.

MOST tables of determinations of the velocity of light contain misstatements which seriously detract from their utility. Moreover, there seems to be no table available giving a fairly complete summary of the work which has been done to ascertain the exact value of this most important constant.

The following table has been compiled, from the original communications contributed by the investigators themselves, for the purpose of meeting this want. It contains every value which has been deemed by the author of the observations to be worthy of being stated as the result of a completed series of experiments, in the course of the work which ultimately led to a final value adopted as representing best the result of this work.

The history of the quest for the value of the velocity of light is conveniently divided into three periods, and the table has been accordingly divided into three sections, in a manner which the headings render self-explanatory.

The letters *TW* refer to the toothed wheel (or 'eclipse') method and *RM* to the revolving mirror method. These two methods which, although both of French origin, have become characteristic of European and American practice respectively, are classical and need no further explanation here. References to the original papers, etc., are given after the table, with brief remarks where necessary. In most cases the data have been left in the form in which they were given by the investigator or by the author of the paper, etc., himself (except that all the values of the velocity have been expressed in the same unit: kilometres per second), even when a modification suggested itself, such as when the velocity in air only was given, or when the velocity was stated with a degree of accuracy which is evidently unwarranted owing to the residual uncertainty attaching to the determination.

Not infrequently it has been impossible to ascertain the average date of a series of experiments, and in such cases, after careful consideration of the available evidence, a date has been adopted which appears to represent fairly the most probable position of the observations on the chronological scale. The values being tabulated in chronological order, it follows that mean values (to which a mean date has been assigned)

are placed in the table before some of the determinations concurring in its formation. The determination of a velocity being dependent on the value of the unit of time, and the latter being determined by the time of rotation of the earth, which is suspected of variation, it is thought that the exact date may become useful in the view of further advance in knowledge, and it is desired that the table be no more found wanting in this respect than in others.

It is seen from the table that there are seven, and only seven, determinations which may be considered as trustworthy.

(In the discussion below, the abbreviated references are to publications listed at the end of this article.)

No.	Average date.	Investigator.	Method.	Length of base.	Base.	Velocity, km./sec.	Medium.	Remarks.
				FIRST PERIOD: PIONEER EXPERIMENTS				
1	1849·5	Fizeau	TW	8,633 m.	Suresnes—Montmartre	315,300	Air	
2	1862·8	Foucault	RM	20 m.	Paris Observatory	298,000 ± 500	,,	
				SECOND PERIOD: CHIEFLY WITH SHORT BASES				
3	1872·0	Cornu (*a*)	TW	10,310 m.	Ecole Polytechnique—Mont Valérien	298,500 ± 300	Air	Preliminary value (rejected as doubtful).
4	1874·8	,, (*b*)	,,	22,910 m.	Paris Observatory—Monthéry	**300,400 ± 300**	Vac.	
5	,,	Cornu-Helmert	,,	,,	,,	**299,990 ± 200**	,,	Cornu's results discussed by Helmert.
6	1878·0	Michelson (*a*)	RM	1986·23 ft.	U.S. Naval Academy	300,140 ± 300	,,	Preliminary value (discarded).
7	1879·5	,, (*b*)	,,	,,	,,	**299,910 ± 50**	,,	Corrected value.
8	1880·9	Newcomb (*a*)	,,	2550·9 m.	Fort Meyer—U.S. Naval Observatory	299,627	Air	Doubtful.
9	1881·0	Young and Forbes	TW	18,212·2 ft. and 16,835·0 ft.	Wemyss Bay—Hills behind Innellan	301,382	Vac.	Admittedly unreliable.
10	1881·7	Newcomb (*b*)	RM	3721·2 m.	Fort Meyer—Washington Monument	299,694	Air	Doubtful.
11	1881·8	,, (*c*)	,,	—	—	299,810	Vac.	Mean of (*a*), (*b*), and (*d*).
12	1882·7	,, (*d*)	,,	3721·2 m.	Fort Meyer—Washington Monument	**299,860 ± 30**	,,	Final declared value.
13	1882·8	Michelson (*c*)	,,	2049·532 ft.	Cave School of Applied Science, Cleveland	**299,853 ± 60**	,,	
				THIRD PERIOD: WITH VERY LONG BASES				
14	1900·4	Perrotin (*a*)	TW	11,862·2 m.	Nice Observatory—La Gaude	299,900 ± 80	Vac.	Preliminary discussion (superseded).
15	1900·4	,, (*b*)	,,	,,	,,	300,032 ± 215	,,	Final discussion (discarded).
16	1901·4	,, (*c*)	,,	—	—	299,880 ± 50	,,	Mean of (*a*) and (*d*) (superseded).
17	1902·4	,, (*d*)	,,	45,950·7 m.	Nice Observatory—Mont Vinaigre	299,860 ± 80	,,	Preliminary discussion (superseded).
18	1902·4	,, (*e*)	,,	,,	,,	**299,901 ± 84**	,,	Perrotin's final declared value.
19	1924·6	Michelson (*d*)	RM	35,385·53 m.	Mt. Wilson Observatory—Mt. St. Antonio	**299,802 ± 30**	,,	Preliminary (corrected) value.
20	1926·0	,, (*e*)	,,	,,	,,	**299,796 ± 4**	,,	
21	In progress	,, (*f*)	,,	About 131 km.	Mt Wilson Observatory—Mt. San Jacinto	Not yet published	,,	

(1) [i, vol. 29, 1849, p. 90] and (2) [i, vol. 55, 1862, p. 501] are admittedly but rough approximations, the experiments being intended to ascertain the possibilities of the method. The unreliability of the second determination may be estimated from the fact that the deflexion from which it was deduced was only 0·7 millimetres (ii, p. 233). The first result is undoubtedly far too high, and the second is much too low. There appears to be little to choose between the two, although the second method is more likely to be the less inaccurate, being simpler in technique and of easier application. One seems justified in taking their mean.

W. Harkness (Washington Observations for 1885, Appendix III. p. 29, under the heading "Velocity of Light *in vacuo*," gives as being Fizeau's value "70,948 lieus (*sic*) of 25 to a degree=315,324 kilometres." The former value is not the value *in vacuo*, and how the equivalent in kilometres was obtained is not stated. Harkness also gives as Foucault's value 298,574 ± 204, stating that this is the final result obtained from 80 observations made on Sept. 16, 18 and 21, 1862. This information is derived from the "Recueil des Travaux Scientifiques de Léon Foucault," Paris, 1878, which gives (pp. 224 and 225) the dates and numerical results of Foucault's observations on the velocity of light, made between May 22 and Sept. 21. The value still given in this "Recueil," however, is the same as that given in the *Comptes rendus*, namely, "298,000 kilometres par seconde de temps," and it is not apparent how the value given by Harkness is obtained from the data given in the "Recueil."

(3) [iii, p. A 298, footnote] was rejected by Cornu as being affected by serious systematic errors.

(4) [iii and i, vol. 79, 1874, p. 1361]. In the *Annales* (p. A 293) the velocity is given as 300,350 in air, the additive correction to vacuum being 82; the final velocity is 300,400. In the *Comptes rendus* (p. 1363) the velocity in air is given as 300,330, and the final velocity in vacuum, obtained by multiplying by 1·0003, is 300,400. Cornu, therefore, evidently concerns himself with four significant figures only. Newcomb [vi *b*, p. 202] gives wrong years for these determinations, and the errors are copied (xi) by Michelson and Preston ("The Theory of Light," 1901 ed., p. 511).

(5) [iv, vol. 87, 1876, col. 123]. Cornu protests strongly against the treatment his results have suffered in Helmert's hands [ii, p. 227, footnote]. The probable error is estimated by Todd [v, p. 61].

(6) and (7) [vi *a*]. The first value was discarded by its author owing to its large probable error (*loc. cit.*, pp. 115-116) compared with the greater accuracy of the subsequent determination. The latter was given as 299,944 ± 51, and rounded to 299,940 ± 50 (*loc. cit.*, p. 141). A correction was announced later on [vi *c*, p. 244], reducing it to 299,910 ± 50. Newcomb, when mentioning this correction, misquotes the original value, giving it as 299,942 [vi *b*, p. 119, footnote]. Todd [v, p. 61] refers to this value as given in the 'corrected slip,' but gives 299,930; no confirmation could be found.

(8) and (9) [vi *b*] are declared by Newcomb to be doubtful owing to the presence of systematic errors. "The preceding investigations and discussions seem to show that our results should depend entirely on the measures of 1882" (*loc. cit.*, p. 201). He does not trouble to reduce them to vacuum, and he does not mention their probable errors. It is only with evident reluctance, and to avoid criticism (*loc. cit.*, p. 201-2), that he includes them in a mean value (11), with (12) which is clearly the value which he favours as most reliable (*loc. cit.*, p. 202).

(9) [vii, p. 231]. Two distant reflectors, in line with the source of light at the observing station, were used so as to have two images. Other experimental features, however, were detrimental to the obtainment of good results, and this determination was severely criticised by Newcomb [vi *b*, p. 119] and by Cornu [ii, p. 229]. The result is given by the authors with an unwarranted accuracy (*loc. cit.*, p. 269), but they give no probable error.

(13) [vi *c*]. The agreement between this value and Newcomb's last determination (*d*), obtained *practically simultaneously*, is worthy of remark; it seems to show that the accuracy was greater than the probable errors seem to indicate.

(14) [i, vol. 131, 1900, p. 731], and (17) [i, vol. 135, 1902, p. 881] were evidently announced as soon as a preliminary reduction had been carried out. Their average (16) is given in the second communication (p. 883), and is generally quoted as Perrotin's final value, although these results were considerably modified in the course of the final discussion (*vide infra*, (15) and (18)).

(15) and (18) [viii]. Incredible as it may seem, this final discussion of the experiments first reported in the *Comptes rendus* (*vide supra*, (14) and (17)), makes no mention whatever of the results mentioned in these first communications. It is necessary to compare the observations themselves in order to ascertain that (*a*) and (*b*) are deduced from the same first series of observations, while (*d*) and (*e*) are deduced from the second series. The confusion is increased by the fact that (*e*) is so nearly identical with (*a*) that the latter seems to be the former rounded off, while they are actually obtained from two different series of observations over different bases. Prof. Michelson did not avoid this pitfall, and quoted Perrotin's final result as having been obtained over the shorter base instead of the longer one [x and xiii].

(19) [ix *a*, p. 256] was first given as 299,820, but a correction given later on [ix *b*, p. 2] reduced it to 299,802. It is given separately here, although, ultimately, it was 'lumped up' with others to obtain a mean, because it was evidently deemed by its author to be of sufficient accuracy to be published at once, which was not the case with any other preliminary results obtained before.

(20) [ix *b*, p. 1] is the most accurate value yet published. It is the average of several series of observations made with multi-facet mirrors, all of which are in agreement within ± 1 km./sec.

(21) [ix *b*, p. 12] is announced as being in progress; the base is the longest ever used, Perrotin hitherto holding the record. It is expected to be accurate to within 1 km./sec.

The following values have also been mentioned by certain authorities, no confirmation having been obtainable.

(22) [x and xiii]. In the "table of results of the more important investigations to date," Prof. Michelson gives for his own results (presumably from the observations made in 1878–1882) the value 299,895. It is not known how it is derived. It is not the average of (*a*), (*b*), and (*c*).

(23) Abraham and Sacerdote ("Recueil de Constantes Physiques," Table 166) give 299,890 as having been obtained by Michelson in 1902. No determination appears to have been made by Michelson at about that time, but, in that year 1902 he published a paper [xi, p. 6, and xii, p. 334] in which he adopted this particular value as the most probable estimate to date, being an average of the results obtained by Cornu ("discussed by Listing," *vide infra*), Newcomb, and himself. Is this the origin of the value given in the "Recueil"?

(24). A value 299,990, alleged to have been obtained by Listing from a rediscussion of Cornu's observations is mentioned by Newcomb [vi *b*, p. 202], by Michelson, *quoting Newcomb* [xi and xii, p. 333], and by Preston (*loc. cit.*, p. 511) also *quoting Newcomb*. No trace of such a discussion by Listing could be found, but Helmert [iv, vol. 87, 1876, p. 123] obtains precisely this value 299,990 by rediscussing Cornu's results. This value, obtained by Helmert, is quoted correctly by Michelson [vi *a*, p. 144], by Todd [v, p. 61] and by Cornu [ii, p. 227]; it only masquerades as Listing's in Newcomb's Report and *in later works quoting or copying Newcomb*. Occasionally, however, Michelson refers to this value as Listing's *even when referring to another work in which it is attributed to Helmert* [xii, p. 334, l. 33]! As shown above, Newcomb made several errors of transcription, or misquoted from memory, and these were copied indiscriminately by Michelson and Preston. The evidence is fairly strong in favour of Newcomb attributing wrongly the value to Listing (who had just published a paper [iv, vol. 93, 1878, p. 369] on the solar parallax ("Einige Bemerkungen die Parallaxe der Sonne betreffend"), and that Listing's discussion of Cornu's results is non-existent. Later [x and xiii], Michelson gives Cornu's result as 299,950. This is neither Cornu's, nor Helmert's, nor "Listing's," as hitherto quoted by him and others after Newcomb; what it is could not be ascertained. It would be highly desirable that the confusion already existing should be prevented from spreading by the exertion of a little care in giving the origin of any information which cannot be traced directly to its authentic source.

The following abbreviations have been used for references which occur more than once:

i. *Comptes rendus des séances de l'Académie des Sciences, Paris.*
ii. "Rapports présentés au Congrès International de Physique," 1900, vol. 2.
iii. *Annales de l'Observatoire de Paris*, vol. 13, 1876.
iv. *Astronomische Nachrichten.*
v. *American Journal of Science*, 3d Series, vol. 19, 1880.
vi. *a. Astronomical Papers for the American Ephemeris and Nautical Almanac*, vol. 1, Part 3.
vi *b. Astronomical Papers for the American Ephemeris and Nautical Almanac*, vol. 2, Part 3.
vi *c. Astronomical Papers for the American Ephemeris and Nautical Almanac*, vol. 2, Part 4.
vii. *Philosophical Transactions*, 1882, vol. 173, Part 1.
viii. *Annales de l'Observatoire de Nice*, vol. 11, 1908.
ix *a. Astrophysical Journal*, vol. 60, 1924.
ix *b. Astrophysical Journal*, vol. 65, 1927.
x. *Journal of the Franklin Institute*, November 1924, p. 627.
xi. *Decennial Publications of the University of Chicago*, vol. 9, 1902.
xii. *Philosophical Magazine*, 6th Series, vol. 3, 1902.
xiii. NATURE, Dec. 6, 1924, p. 831.