will not only be felt in that elementary, but will also penetrate into secondary education. In regard to the additions which are required in elementary education, and which require the proper training of the pupil teacher, I must refer you to a report which will be presented to the section. The task of training pupil teachers is one which requires the earnest and undivided thought of the new education committees.

In the earnest address given by my predecessor in this chair he brought forward the shortcomings of secondary education and of the requirements for a military career in a trenchant manner and with an ability which I can not emulate. With much of what he said I agree heartily, but I can not forget that, after all, the details of education are to some extent matters of opinion, though the main features are not. We must be content to see advances made in the directions on which the majority of men and women educational experts are agreed. Great strides have already been made in educating the public both in methods and subjects, but a good deal more remains to be done.

It may be expected, for instance, that the registration of teachers will lead to increased efficiency in secondary schools, and that the would-be teacher, fresh from college, will not get his training by practising on the unfortunate children he may be told off to teach. It may also be expected that such increased efficiency will have to be vouched for by the thorough inspection which is now made under the board of education act, by the board, by a university, or by some such recognized body. It again may be expected that parents will gradually waken up to the meaning of the teacher's register and the value of inspection, and that those schools will flourish best which can show that they too appreciate the advantages of each.

I have to crave pardon for having failed to give an address which is in any way sensational. I have thought it better to review what has been done in the past within my own knowledge, and with this in my mind I can not but prophesy that the future is more than hopeful, now that the public is beginning to be educated in education. It will demand, and its wants will be supplied.

WILLIAM DE W. ABNEY.

APPENDIX.

Number of Schools of Science and their Grants.

Year.	Higher Grade Schools.	Endowed Secondary Schools.	Technical Institutes.	Total Schools.	Total Grants.
					£
1895	53	30	29	112	39,163
1898	69	50	49	168	98,849
1901	63	106	43	212	118,833
1903	50	119	57	226	Not yet known.

Number of Schools teaching Shortened Course of Science.

Year.	No.
1902	127
1903	184

Number of Laboratories Recognized.

Year.	Chemistry.	Metallurgy.	Physics.	Biology.	Mechanics.
1880	133	—	—	—	—
1900	669	37	219	17	4
1901	722	37	291	26	10
1902	758	39	320	34	14

Grants paid for Science Instruction.

Year.	Amount.	Year.	Amount.
	£		£
1860	709	1890	103,453
1870	20,118	1895	142,543
1875	42,474	1901	212,982
1880	40,229	1902	240,822
1885	63,364		

*THE LONGITUDE OF HONOLULU, VARIOUS DETERMINATIONS, 1555–1903.**

THE occasion for this article is the recent determination by the telegraphic method of the difference of longitude of San Francisco and Honolulu through the new Pacific cable by Messrs. Edwin Smith and Fremont Morse, of the Coast and Geodetic Survey.

The first signals over this portion of

* Read before the Philosophical Society of Washington, October 10, 1903.

the cable were sent on January 1, 1903. The cable was opened for public use on January 5, 1903. The first observations in the telegraphic determinations of longitude were secured on April 20.

The cable company cooperated with the government by aiding the observers in various ways, and by granting the free use of the cable during a short period each night for their work.

Between April 20 and June 13 eleven determinations of the difference of longitude were made, five with the observers in one position and six after they had exchanged places for the purpose of eliminating the effects of their relative personal equation. The total range of the eleven results was only 0.17 s. No result differed from the mean by as much as one tenth of a second.

This degree of accuracy corresponds to that usually attained in determinations of the difference of longitude of two places connected by a telegraph line overland. Until within a few years such a degree of accuracy had not been possible for determinations made through long cables. The increase in accuracy has apparently been due to improvements made in the recording apparatus used by the cable companies.

The difference of longitude of the transit piers in San Francisco and Honolulu, respectively, was found to be, from the field computation, 2 h. 21 m. 38.92 s.

A revision of the computation still remains to be made, but the changes in this result will be very small. The chances are even for and against the difference stated, being within 0.03 s. of the truth.

The longitude of San Francisco from Greenwich is fixed by four transatlantic determinations by the telegraphic method, 1866, 1870, 1872 and 1892, and by a complicated telegraphic longitude net stretched across the United States.

The longitude of the Transit of Venus pier at Honolulu, as fixed by the new determination from San Francisco, is 10 h. 31 m. 27.24 s. west of Greenwich. Taking into account all the uncertainties in the chain of observations between Greenwich and Honolulu, the chances are even that the value stated is correct within 0.06 s., and it is almost certain that it is not in error by as much as 0.2 s. In the latitude of Honolulu 0.06 s. of longitude corresponds to 85 feet, or 1 s. to 1,418 feet.

The observers, Messrs. Smith and Morse, are still engaged in determining the differences of longitude over the three other spans of the cable between Honolulu and Manila. A good determination of the difference Manila–Guam has already been secured. When their work is complete the longitude of Manila will have been determined telegraphically in both directions around the world from Greenwich, and the longitude girdle of the earth will be complete.

The following résumé of various determinations of the longitude of Honolulu is condensed from an account furnished by Mr. W. D. Alexander, formerly Surveyor-General of the Hawaiian Islands, and now an assistant in the Coast and Geodetic Survey. It is especially interesting as showing the comparison of various determinations of a large difference of longitude by a variety of methods and extending over three and a half centuries.

In the following tabular statement the new determination of the longitude of the Transit of Venus station, 10 h. 31 m. 27.2 s., is taken as being correct in deriving the errors of the various determinations. In cases in which the older determinations referred to some other point than the Transit of Venus station, they have been reduced to that station by using the relations in position which are now known.

	Longitude of Transit of Venus Pier, Honolulu.	Error of Longitude.
	h. m. s.	
John Gaetano, 1555, no chronometers, no log	9 23	—68m
Cook, 1785, observatory on Hawaii	10 31 45	+18s
Vancouver, 1790, based on Cook, various points	45 to 27	+18 to 0
Freycinet, 1819	26	— 1
Wilkes, 1840, based on Cook	35	+ 8
Lyman, 1845–1846, moon culminations, predicted places	15	—12
Fleuriais, 1868, 27 moon culminations, first computation	21.8	— 5.4
Fleuriais, 1868, second computation	25.9	— 1.3
Tupman, 1874, 700 culminations, 13 occultations, 540 zenith distances of moon, first computation	15	—12
Tupman, 1874, second computation	27.2	0.0
Tupman, 1874, combined with first computation of Fleuriais	26.3	— 0.9
Tupman, 1874, combined with second computation of Fleuriais	26.7	— 0.5
Tupman, 1875, 20 chronometers, one trip, Honolulu to San Francisco.	33.2	+ 6.0
Hawaiian Government Survey, 1884, chronometers, 2 round trips, Honolulu to San Francisco	25.8	— 1.4
Hawaiian Government, adopted in furnishing time	26	— 1.2
Hawaiian Government, adopted for mapping purposes	27.2	0.0

In the Spanish chart found by Lord Anson on board the galleon which he captured in 1743, a group of islands was laid down in the same latitude as the Hawaiian Islands, but 17° too far east.

The southernmost and largest island was named La Mesa, which seems to refer to Hawaii with its high tableland. North of it were La Desgraciada, probably Maui; and three small islands called Los Monjes, which may have been Kahoolawe, Lanai and Molokai.

This chart was published in the narrative of Lord Anson's voyage in 1749.

An official letter from the Spanish Hydrographical Department to the Hawaiian Government, dated Madrid, February 21, 1865, states that an ancient manuscript chart exists in the archives of that office, in which this group is laid down as in the chart of the Spanish galleon, with the name 'Islas de Mesa,' and a note declaring that they were discovered and named by Juan Gaetano in 1555.

The large error in the longitude of La Mesa, of 17°, more than 1,000 nautical miles, is not surprising when it is considered that chronometers were not yet dreamed of, that the Spanish navigators depended entirely on dead reckoning for their longitudes, that the use of the log for measuring the velocity of a ship was not known before 1607, and that the equatorial current would be effective in producing an error of the sign actually found. Thus La Pérouse, coming from California, found that the error in his dead reckoning caused by this current, when he arrived off Hawaii, amounted to 5° to the east, and Vancouver, coming from the south, found a similar error from the same cause, amounting to 5°14′.

When Captain Cook discovered Hawaii, in 1768, he was not aware that he had accidentally rediscovered La Mesa, and his successors at first retained both La Mesa and the Sandwich Islands on their charts, as may be seen in the atlas accompanying the early editions of Cook's 'Voyages.'

Seven years later, in 1785, two of Cook's officers, Portlock and Dixon, on their way to the northwest coast, as their crews were suffering from scurvy, headed their ships for the supposed position of La Mesa, sailed over it, and ran down the parallel of latitude till they arrived at Hawaii. A few days later La Pérouse, after searching in vain for La Mesa, did the same, and be-

came convinced of its identity with Hawaii.

The charts attached to the early editions of Cook's 'Voyages' placed Kealakekua Bay at 156°00′, or 18 s. too far west.

Although chronometers were put into use prior to 1714, as late as 1762 John Harrison won a reward of 20,000 pounds from the British government for having constructed a chronometer which, according to the test made, determined the difference of longitude of Portsmouth, England, and Jamaica within eighteen miles. The prize in question was offered in 1714, and it took 47 years to make sufficient improvements in chronometers to win it. Captain Cook's error of only 18 s., or four and one half miles in the longitude of Honolulu was, therefore, remarkably small for that time.

Captain Vancouver, in 1790, adopted the same longitude of Kealakekua as Captain Cook, viz., 156° 00′. The true longitude of Cook's observatory there is about 155° 55′ 30″. Vancouver gives for the longitude of his anchorage off Waikiki, Oahu, 157° 50′ 23″ w., which is only half a mile too far west, and for Wiamea, Kauai, 159° 40′ w., which is probably within a quarter of a mile of the true longitude.

Captain Freycinet, of the scientific exploring ship *L'Uranie,* in 1819, made the longitude of Kealakekua 156° 04′ 23″.5 w. from Greenwich, which is 36 s. too far west. He made the longitude of Honolulu 157° 51′ 46″.2 w. from Greenwich, which is about 1 s. too far east.

Commodore Chas. Wilkes, of the U. S. exploring expedition, in 1840, adopted Captain Cook's longitude of Kealakakua Bay, viz., 156° 00′ w., and placed Honolulu at 157° 54′ w., and Waimea, Kauai, at 159° 44′ 30″, both of them 8 s. too far west.

During the years 1845–6 the late Professor Chester S. Lyman, afterwards a professor at Yale University, who was then residing in Honolulu for his health, assisted Mr. David Flitner, chronometer maker, in establishing a small observatory here, and made a series of meridional observations of the moon, in order to determine the longitude. The result he obtained, using the *predicted* places of the moon in the American 'Ephemeris,' was 10 h. 37 m. 15 s. w., or 12 s. too far east.

In the year 1868, M. Fleuriais, in the service of the 'Bureau des Longitudes,' who came to observe a transit of Mercury at Honolulu, established an observatory near the Catholic Cathedral, where he observed nineteen meridional transits of the moon's first limb, and eight of the second limb. These observations are published in detail in the appendix of the *Connaissance des Temps* for 1872. The result, as first published, was 160° 10′ 38″ west of Paris, or 157° 50′ 23″.5 w. of Greenwich, or 5.4 s. too far east.

But in No. 2586–7 of the *Astronomische Nachrichten,* for April, 1884, we find a reduction of Fleuriais' observations for longitude, carried around the world in 1867–70. On pages 345–6 are given the single results obtained in Honolulu in October–December, 1868, 27 in number, and the longitude deduced from them is 10 h. 31 m. 25.59 s., or 1.3 s. too far east. These results were obtained by combining the observations at Honolulu with the actual observations of the moon's place made during the same period at Washington, Greenwich and Paris.

In September, 1874, Captain G. L. Tupman, Royal Marine Artillery, in charge of the British Transit of Venus Expedition of that year, arrived in Honolulu, and established an observatory on Punchbowl Street, near the shore, on practically the same meridian as C. S. Lyman's observatory, and 4″.79 west of Fleuriais' pier. No pains were spared to ascertain the longi-

tude by lunar observations, and the accuracy of the work has since been fully confirmed.

The observations for longitude were continued through the months of October, November and December, 1874. During this time over 700 meridional transits of the moon, thirteen occultations of stars, and about 540 zenith distances of the moon's upper and lower limbs, combined with those of well-known stars near the moon, were observed. The first reduction of the observations apparently agreed with the result obtained by Professor Lyman, viz., 10 h. 31 m. 15 s., but after returning to Europe and correcting the tabular right ascension by the contemporary observations made at Washington, Greenwich, Paris, Königsburg, Strasburg and the Cape of Good Hope, Captain Tupman increased the result by about twelve seconds of time. His final result by meridional transits of the moon was 10 h. 31 m. 26.0 s.; by zenith distances, 10 h. 31 m. 27.3 s.; by occultations of stars, 10 h. 31 m. 26.9 s.

The result officially communicated to the Hawaiian Government Survey was 10 h. 31 m. 27.2 s., upon which all the maps since then have been based. It is interesting to note that this value agrees to the tenth of a second with the latest determination of the longitude.

Captain Tupman, however, afterwards weighted the above results according to the number of observers employed on each, giving the occultation result the weight 5, the mean of the first two results the weight 4 and M. Fleuriais' result the weight 1, on which conditions the resulting longitude is 10 h. 31 m. 26.3 s. If he had used the value deduced from Fleuriais' work by the *Astronomische Nachrichten,* his final mean would have been 10 h. 31 m. 26.7 s.

In March, 1875, Captain Tupman made an attempt to connect Honolulu with San Francisco by transportation of chronometers. Accordingly twenty chronometers were carried by H. B. M. S. *Reindeer,* Commander C. V. Anson, from Honolulu to the U. S. Navy Yard, Mare Island, and compared with the local time at both stations. Unfortunately the *Reindeer* was blown out of her course by a northerly gale, which lengthened her voyage seven or eight days, and lowered the temperature in the chronometer boxes as much as 15° F. Hence the resulting determination of the longitude of Honolulu, viz., 10 h. 31 m. 33.2 s. ± 3.0 s. w., had very little value.

Again, in August and September, 1884, an attempt was made by the Hawaiian Government Survey with the cooperation of Professor Davidson and Mr. Morse in San Francisco, to determine the longitude of Honolulu by comparing the chronometers on board the O. S. S. Co. steamer *Mariposa,* with the local time at each end. This was done for two round trips, giving a mean result of 10 h. 31 m. 25.8 s.

In view of all the above facts, the Hawaiian government adopted 10 h. 31 m. 26.0 s. as the most probable value, in rating chronometers and furnishing standard time, but not for mapping, until the recent telegraphic determination made by the U. S. Coast and Geodetic Survey.

JOHN F. HAYFORD.

SCIENTIFIC BOOKS.

A Discussion of Variable Stars in the Cluster ω Centauri. By SOLON I. BAILEY. Annals of the Astronomical Observatory of Harvard College, Vol. 38. 4°. Cambridge, Mass. 1902. Pp. 252; 13 plates.

Among the most interesting discoveries in the subject of variable stars during the last decade belongs the finding of an exceptionally large number of variables in certain globular star clusters. The remarkable fact that in many of these systems a not insignificant proportion of all the stars change their light