take away 8 of them, this suggestion seems as unthinkable as the suggestion of a fourth dimension. But when men chose to represent by —3 the result of subtracting 8 from 5, instead of simply saying it was impossible, then the foundation was laid for the enormously useful science of Algebra.

The assumption of a fourth dimension has not as yet led to any noteworthy useful results, but it is by no means impossible that the science of four-dimensional geometry may come to have useful applications. It has been suggested by Prof. Karl Pearson that an atom may be a place where ether is flowing into our space from a space of four dimensions. It can be shown mathematically that this would explain many of the phenomena of matter. At the present stage, the suggestion is regarded, even by its author, as merely fanciful, though it is not as fanciful as the proposition of the German spiritualists who regard the fourth dimension as the abode of their disembodied spirits.

SOME NEW WARSHIPS AND THEIR EQUIPMENT.

(*Concluded from page 56.*)

been entered upon seriously, and four battleships were laid down simultaneously in Baltic yards on June 16th. The "Sevastopol" and "Petropavlovsk" are building at the Baltic works and the "Poltava" and "Gangut" at the new Admiralty yard, the English firm of John Brown & Co. being in charge of the work. On a displacement of 23,000 tons they will carry twelve 12-inch guns, arranged as shown, as well as sixteen 4.7's and four torpedo tubes. The speed will be 24 knots and the horse-power 42,000, which is very high for battleships. Meanwhile four other battleships which were laid down in 1903—the "Imperator Pavel" and the "Andrei Pervozvanni" in the Baltic and the "Ioann Zlatoust" and "Evstafi" in the Black Sea—are still incomplete.

It is only four years since the first all-big-gun ship was laid down; but the following table will show how completely the idea has seized upon the naval powers. It shows the number of battleships of this type completed, under construction, or to be laid down this year:

TABLE SHOWING TOTAL GUN POWER OF "DREADNOUGHTS."

	Great Britain.	Germany.	United States.	Austria.	Italy.	Russia.	Brazil.	Spain.	China.	Japan.	Chili.	Argentine.
Eight 14-in...	....	...	....	....	2 or 0		..	....	....	....	..	....
Ten 13.5-in...	4 or 5	..	....	..	....	.	...	....	..	...	...	....
Twelve 12-in.	0	6 ?	2	...	2 or 4	4	3	0	...	2	..	...
Twelve 11-in.	....	7 or 6	...	..	..		....	.	....	....	...	..
Ten 12-in.....	8 or 7	.	4	4	..	..	....	....	....	....	2 ?	2
Ten 11-in....	..	0 or 1	...	....			...	..	....	....	....	...
Eight 12-in...	4		2				.	3	3 ?	..		.
Tot'l in ships of this type	152	156 or 154	80	40	48 or 40	48	36	24	24	24	20	20

We also present a table which analyzes these vessels according to their main armament. It will be seen that, but for her four ships of this year's programme, British designs would "put up a poor show."

	Battleships.	Cruisers.
Great Britain	12*	4
Germany	10	3
United States	8	0
Austria	4	0
Italy	4	0
Russia	4	0
Brazil	3	0
Spain	3†	0
China	3‡ (projected)	0
Japan	2	0
Chili	2 (projected)	0
Argentine	2	0
	57	7

* Besides four "provisional" ships. †Eight 12-inch. ‡15,000 tons. Query "Dreadnought" type.

OPENING OF THE DOWN-TOWN HUDSON TUNNELS.

(*Concluded from page 57.*)

ing the eye, must afford a contrast generally garish and out of harmony with the otherwise excellent and subdued decoration.

This is doubtless a considerable source of income, difficult to forego in these commercial days; but considering the dignity and lack of ostentation with which the Hudson Companies have carried out both delicate negotiations and difficult engineering feats, considering also the immense profits likely to accrue from their undertakings, one might have hoped that they would omit this rather cheapening feature.

Stairways lead down from the concourse to the five platforms below, at each of which in rotation, separated by only 1½ minutes during "rush" hours, trains arrive by the southern and depart by the northern tube, there being no switching, and everything tending to the most rapid handling of traffic. Each train discharges its passengers upon the platform on one side of it and receives its new load from the platform at the other side, an arrangement which entirely separates incoming from outgoing passengers.

Again, below the rail level are extensive baggage and store rooms, and a subsidiary power station, making the Hudson Terminal Building a veritable city in itself, with clubs at the top, multitudinous business offices in between, a post office, telegraph office, and numerous shops below, and a railway station and power station in the basement, all inclosed within four walls.

THE SCIENTIFIC WORK OF THE LATE PROF. SIMON NEWCOMB.

Prof. Simon Newcomb died on July 11th in Washington at the age of 74. His death has removed not only the most distinguished astronomer that America ever produced, but a man who is honored the world over for his monumental scientific achievements.

All Newcomb's work followed up with rare perseverance has constantly tended to this ideal end: First, to arrive at a more exact knowledge of the magnitudes serving as points of reference and then to establish the theory not only of all the planets but also of their satellites on a system of constants as precise as modern observations permit.

Shortly after he graduated from the Lawrence Scientific School at Cambridge, he began the first important problem with which his name is associated, namely, the motions and orbits of the asteroids which revolve about the sun between Mars and Jupiter. It was once thought that perhaps these numerous bodies might be fragments of a large planet which had been shattered by explosion or collision. Were this true, the orbits would pass through the point at which the explosion occurred. As more and more asteroids were discovered, the coincidences of orbits became less marked. Still the theory was adhered to, because it was thought possible that the attraction of the larger planets might have caused perturbations. In order to decide for or against the theory, it was necessary to discover general formulæ by which the positions of the orbits could be determined at any time in the past, so that it could be ascertained whether or not the orbits ever did pass through a common point of explosion, in which case it would be possible to give an approximate date for the catastrophe. As a result of Newcomb's painstaking investigation, he concluded that the orbits had never passed through any point of common intersection. Later investigations based on Newcomb's work have shown that the hypothetical cataclysm never occurred, and that the asteroids probably always existed as minor planets. The paper which Newcomb read on the subject at the Springfield meeting of the American Association for the Advancement of Science in 1859 was the first that brought him into prominence—a young man of but twenty-four.

When Newcomb commenced his work at the Naval Observatory in 1861, the problems of the moon's motion had attracted astronomical attention. The most perfect lunar tables at the time were those of Hansen. Hansen had only a single assistant and could not, therefore, make the great number of observations required in the case of a body moving so rapidly as the moon. For a year or two Newcomb's observations showed that the moon seemed to be falling a little behind her predicted motion. This soon ceased, however, and she gradually forged ahead in a most remarkable way. In five or six years it was apparent that this acceleration was becoming permanent. Astronomers were puzzled to account for the phenomenon. For half a century the moon had apparently been running ahead and had then relaxed her speed so far as to fall behind again. Hansen had suggested that the planet Venus might be responsible for these inequalities. He showed that for 130 years the moon would thus be made to run ahead and for 130 years to fall behind. For 100 years the moon seemed to have followed Hansen's theory. Yet Newcomb found that the moon was deviating. To ascertain whether or not Hansen's tables represented the motion of the moon perfectly since 1750, as astronomers supposed, Newcomb undertook an examination of the occultations of the moon with bright stars. It was not until the telescope had been introduced and used for finding the altitude of a heavenly body and not until the pendulum had been invented by Huyghens that the time of an occultation could be fixed with the required exactness—a task first systematically performed by French astronomers of the eighteenth century. Newcomb suspected that some accurate observations had been made before their time, which he might use in checking up Hansen's tables. He found that a few such observations had actually been made between 1660 and 1700 and discovered to his surprise that Hansen's tables were evidently much in error. But to determine the cause of the errors was impossible without more observations. Newcomb planned a thorough search of the old records of Europe. On the occasion of the solar eclipse of 1870, he was sent abroad to observe the phenomenon for the Naval Observatory. He seized the opportunity to go to Paris and consult the old records of the observatory there. After a search he found that the very observations he wanted had been made in great number by the Paris astronomers, both at the observatory and at other points in the city. Three or four years were spent in making calculations on the basis of these Parisian researches, when it was found that seventy-five years were added in a single step to the period during which the history of the moon's motions could be written. Before Newcomb's work this history was supposed to commence with the observations of Bradley at Greenwich, about 1750. Now it was extended back to 1665, and with a less degree of accuracy farther still. Hansen's tables were found to deviate from the truth in 1675 and subsequent years to a surprising extent. But the cause of the deviation is not entirely unfolded even now.

In 1877 Newcomb took charge of the Naval Almanac Office. He thoroughly reorganized the office and placed it upon a more scientific footing. He mapped out a programme of work which involved a discussion of all the observations of value on the positions of the sun, moon, and planets, and incidentally on the bright fixed stars, made at the leading observatories of the world since 1750—a programme which involved a repetition, in the space of ten or fifteen years, of an important part of the world's work in astronomy for more than a century past. It was impossible to carry out this plan in all its completeness, so that Newcomb was obliged to confine himself to a correction of the reductions already made and published. For all that, the task was one which, in magnitude, probably exceeded any ever before attempted by any astronomer. The number of meridians observed on the sun, Mercury, Venus, and Mars alone numbered 62,030. Still other branches of the Nautical Almanac Office work involved the computation of formulæ for the perturbation of the various planets by one another.

Important among the troublesome problems with which Newcomb had to deal while in charge of the Nautical Almanac was that of universal time. There was a day when every railroad had its own meridians by the time of which its trains were run, which had to be changed here and there in the case of the great trunk lines and which seldom agreed with the local time of a place. The passenger was constantly liable to miss a train, a connection, or an engagement by the doubt and confusion thus arising. All this was remedied in 1883 by the adoption of our present system of standard times of four different meridians, the introduction of which was one of the great reforms of our generation with which Newcomb's name is associated. When the change was made, Newcomb was in favor of using Washington time as a standard, instead of Greenwich. But those who were pressing the measure thought it advisable to have a system for the whole world, and for this purpose the meridian of Greenwich was the natural one.

By 1894 Newcomb had succeeded in bringing so much of his work as pertained to the reduction of the observations and determination of the elements of the planets to a conclusion. So far as the general planets were concerned, it remained only to construct the necessary tables which, however, involved several years' work. Before Newcomb's time, the confusion which pervaded the whole system of exact astronomy, arising from the disclosures of the fundamental data employed by the astronomers of the various countries and various institutions in their work, was such that it was rather exceptional to base any astronomical result on entirely homogeneous and consistent data. To remedy this state of things and to start the exact astronomy of the twentieth century on one basis for the whole world, was one of the plans which Newcomb had mapped out for himself when he took charge of the Nautical Almanac Office. Dr. N. W. Downing, superintendent of the British Nautical Almanac, was animated by the same motive. He had especially in view the avoidance of duplicate work which arose from the same computations being made in different countries for the same result. The field of astronomy is so vast and the quantity of work required to be done so far beyond the power of any one nation that a combination to avoid all such waste was extremely desirable. When Newcomb published his preliminary results in 1895, Downing took the initiative in putting the idea into effect by proposing an international conference of the directors of the four leading ephemerides to agree upon a uniform system of data for all computations pertaining to the fixed stars. This conference was held in Paris in May, 1896.

In 1902, when the Carnegie Institution was organized, it made a grant to supply Newcomb with computing assistants and other facilities necessary for the completion of his study of the moon's motions.

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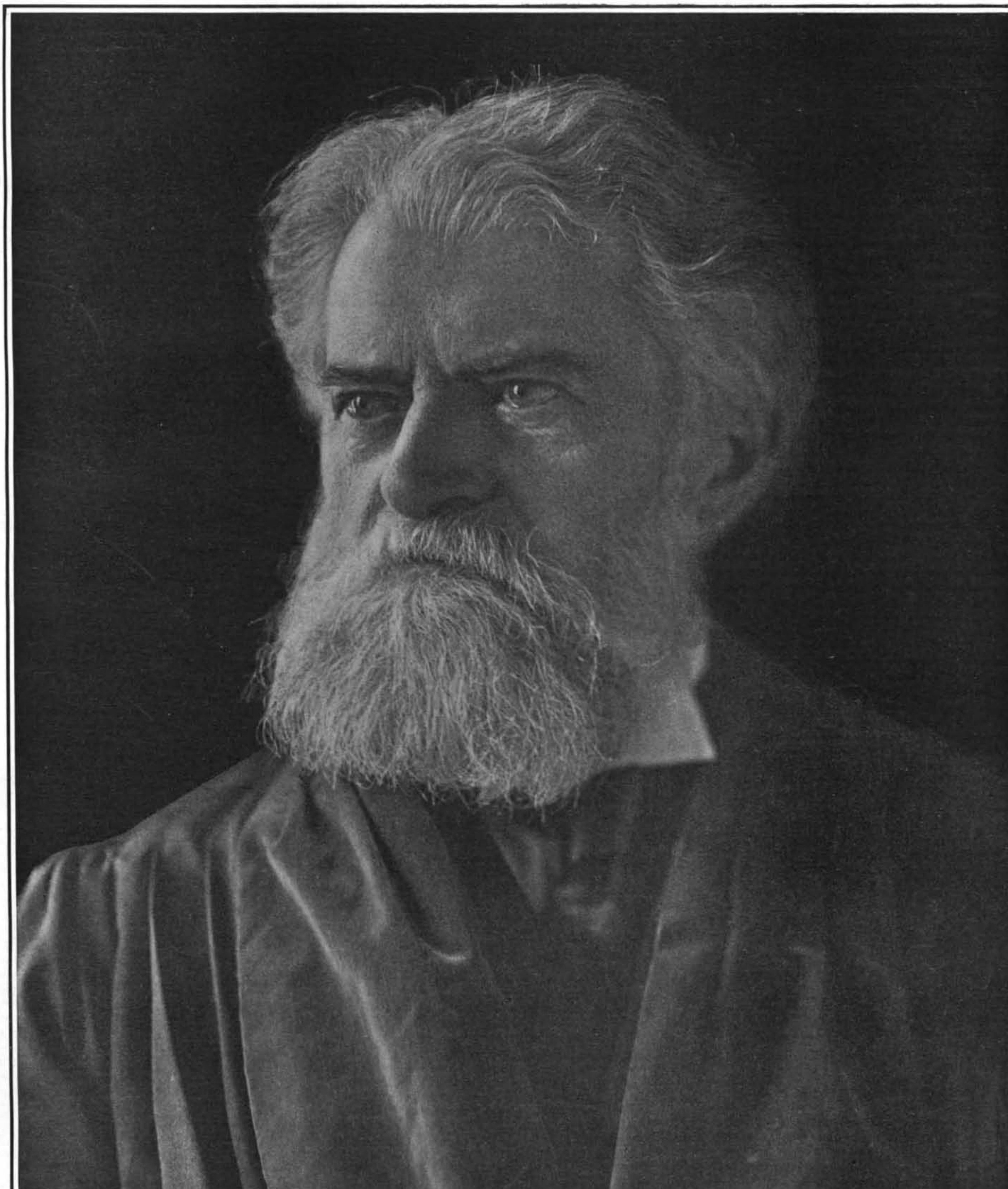

Simon Newcomb

(See page 59.)