Personally I do not fear that our civilization will destroy itself with the aid of its own misdirected inventions. I foresee that more and more the engineers and scientifically trained men will direct the great social activities of government and the large industrial corporations. Science has always recruited from the type of man whose search for truth has been dispassionate. The erudite and the intellectuals have led; the people, knowing the leaders to be disinterested, have followed, and the existing order has been changed by evolution rather than by revolution.

We, in the training schools of the engineer and the pure scientist, must see to it that we train men of this type to take ever more important part in the direction of the affairs of the nation, and we must also see to it that as we are able to raise the standards for entrance we demand a broader cultural foundation on which to build our special training and that we provide opportunities and incentive for further self-culture on the side of the humanities while students are receiving this special training. This may now seem like an impossible counsel of perfection, but competition for desired positions, which has hitherto not been acute, owing to our favored position as a young nation with large national resources, is sure to become greater. Ambitious youth will come to us better trained than at present and we can and must raise our standards of admission and enhance the value of what we have to offer in general and special training.

The points I have tried to make in this speech are the real solidarity of the pure and the applied sciences, that the history of pure science in winning a place in the general educational system has been repeating itself in the case of applied science and that more and more the scientist is going to be called on to render social services to the nation, and that the duty lies on us who are engaged in educating the next generation to plan for a broadening of the cultural base on which we build.

AUGUSTUS TROWBRIDGE

PRINCETON UNIVERSITY,
NOVEMBER 15, 1928

THE APPORTIONMENT SITUATION IN CONGRESS

THE problem of reapportionment in Congress has two interesting aspects, one political and one scientific.

(1) On the political side, an analysis of the vote on the latest reapportionment bill (H. R. 11725, May 18, 1928) shows that the defeat of the bill (186 to 164) was due mainly to the opposition of those states which expected to lose representatives if the bill were passed.

There were seventeen states which expected to lose one or more representatives, namely: Alabama, Indiana (2), Iowa (2), Kansas, Kentucky (2), Louisiana, Maine, Massachusetts, Mississippi (2), Missouri (3), Nebraska, New York, North Dakota, Pennsylvania, Tennessee, Vermont, Virginia. Every one of these states, with the exception of Massachusetts and part of New York, voted against the bill; and the vote within each state delegation (excepting New York and Pennsylvania) was practically unanimous.

On the other hand, there were eleven states which expected to gain one or more representatives, namely: Arizona, California (6), Connecticut, Florida, Michigan (4), New Jersey (2), North Carolina, Ohio (3), Oklahoma, Texas (2), Washington. Every one of these states voted in favor of the bill, the vote within each state delegation being again nearly unanimous.

The first group of 17 states controls 215 members; the second group of 11 states controls 109 members; so that in the two groups together about three quarters of the House is accounted for. The remaining twenty states, controlling 111 members, had nothing to lose or gain by the passage of the bill, and the votes from these states were about equally divided for and against.

It is obvious from this analysis that the political difficulties attending the passage of any reapportionment bill are very great. On the one hand, according to the population estimates for 1930, the only way to avoid loss to any state would be to increase the size of the House to something like 534 members. On the other hand, any proposal to enlarge the House above its present size (435) is certain to meet determined opposition both in and out of Congress.

(2) On the scientific side, there is the question as to the choice of the best method of computation. This scientific aspect of the problem is surprisingly closely related to the political aspect, as the following brief sketch of recent history will show.

The apparently simple arithmetical problem of computing the proper assignment of a specified number of representatives to the several states in proportion to their populations was an unsolved problem for over a hundred years. Up to 1921, no scientific tests of a good apportionment were known; a variety of empirical methods were tried and later discarded, and the decennial debates in Congress were often bitter. Since 1921, however, a series of scientific papers (the latest appearing in the *Transactions* of the American Mathematical Society for January, 1928) has provided a complete mathematical analysis of the problem. It is now known that among all the possible methods, the method of equal proportions is the only one which satisfies the very obvious test of making both the ratio of population to representatives and

the ratio of representatives to population as nearly as possible the same in all the states; furthermore, it has been mathematically demonstrated that this is the only method which has no bias in favor of either the larger or the smaller states.

On these accounts, the method of equal proportions was promptly endorsed in 1921 by a unanimous report of the Census Advisory Committee (published in the *Journal* of the American Statistical Association for September, 1921, and reprinted in the *Hearings* before the House Committee on the Census for both 1927 and 1928), and was later approved by a general consensus of scientific opinion. This was the method specified in the only apportionment bill that came to a vote in the House in 1927 (H. R. 17738, by Mr. Fenn, March 3, 1927); although this bill was defeated by 199 to 187, the debate on the floor of the House showed that the defeat was due entirely to political causes; no objection whatever was raised against the choice of method. Also, the method of equal proportions was the only method mentioned in the bills introduced in the House in the early part of the winter 1927–28 (H. R. 130, by Mr. Fenn; H. R. 209, by Mr. McLeod; H. R. 5519, by Mr. Crail; H. R. 10963, by Mr. Jacobstein). *In all these bills the method of equal proportions was accepted without question as the standard method.*

In February, 1928, however, Professor W. F. Willcox appeared before the House Committee on the Census and urged "amending the bills by changing the method specified in them from the method of equal proportions to the method of major fractions" (*Hearings,* February 21, 1928, p. 88). In this he was entirely successful, and the bill (H. R. 11725) finally reported by the committee on April 4 specified the method of major fractions, on the ground that this method had been used once before in 1911, and that a similar method had been used in 1840.

This eleventh-hour change from the scientific method of equal proportions to the method of major fractions proved to be a distinct hindrance to the passage of the bill, as is shown by a study of the debate on the floor of the House (see the *Congressional Record* for May 17 and 18, 1928).

Many protests were voiced against the method of major fractions on the ground that it was unfair to the smaller states; on the other hand, no arguments were brought up against the method of equal proportions except that it was new. In fact, the chief spokesman for the committee stated that he would be quite willing to vote for a bill specifying the method of equal proportions, and others made it clear that the committee as a whole had no real objection to that method. There was so much feeling on the matter that an amendment was introduced, to reinstate the method of equal proportions; although the amendment failed, as any such amendment would be expected to fail at such short notice, it is significant that any one should have taken the trouble to present the amendment at all. The whole debate made it clear that Congress was thoroughly aroused to the importance of the question of method (which might easily affect half the states in the Union) and was in no mood to accept any method which could not be defended as scientifically fair to all the states. *While the choice of the unscientific method of major fractions was probably not the determining cause of the defeat of the bill, it certainly added appreciably to the political difficulties which the bill had to face.*

(3) The method of equal proportions provides for the first time a direct and simple test of the fairness of any given apportionment; this may be easily explained as follows:

In a theoretically perfect apportionment, the congressional district (that is, the population per representative) in any state A would be exactly equal to the congressional district in any other state B. If, in an actual case, the congressional district in state A is found to be greater than the congressional district in state B by 10 per cent. (say 220,000 against 200,000), then the "disparity" between the two states is said to be 10 per cent. Suppose, in this case, that a transfer of a representative is made from one state to the other; if after the transfer the "disparity" between the states is found to be only 8 per cent., then the apportionment is said to be "improved" by the transfer. This test can be directly applied to settle any dispute between any state and any other state, the only data required being the populations of the two states directly concerned and the number of representatives assigned to each.

A good apportionment, according to the method of equal proportions, is simply an apportionment which can not be further "improved" (in this sense) by any transfer from any state to any other state; in other words, if any transfer were to be made from any state to any other state the "disparity" between the two states (measured as above) would be made worse instead of better by the change.[1]

[1] It is interesting to note that in measuring the "disparity" between two states, the concept of "the population per representative," which was used above, may be replaced, if preferred, by the concept of "the number of representatives per unit population"; the resulting apportionment will be precisely the same. The method of equal proportions may therefore be described as the method which makes both the ratio of population to representatives and the ratio of representatives to population as nearly as possible the same in all the states. It is difficult to see how anything more could be done in the

The modern mathematical theory has shown that, for any given size of the House (say 435) and any given populations of the states (say the 1930 census), an apportionment can always be found which will satisfy this test with respect to every pair of states. It is not necessary, however, to go through the labor of applying the test to every pair of states separately, since the theory has also supplied a short-cut process of computation which is guaranteed to produce the desired result. This technical process of computation is well known to the computers in the Bureau of the Census (*Transactions,* p. 88); but no matter how a proposed apportionment has been computed, the result can be checked up, in case of any dispute, by a direct application of the test.[2]

(4) One feature of the debate is of special interest to students of constitutional history. In his testimony before the House committee (p. 88) Professor Willcox admitted that "a large majority of mathematicians and statisticians are on record in favor of the method of equal proportions"; but he insisted that the problem was properly a constitutional question rather than a mathematical one, and suggested that it be referred to the American Political Science Association for consideration and report (*Hearings,* pp. 49, 88, 89). This suggestion, which was heartily endorsed by the present writer (SCIENCE, May 18), did not lead to any result, since the association "has the feeling that it ought not to undertake to decide a question of this sort" and has therefore taken no action (according to a letter from the secretary, dated September 26, 1928).

Indeed it is hard to see what light the early history of the Constitution can throw on the present-day problem, beyond the obvious fact that the present provisions of the Constitution require that the number of representatives assigned to each state shall be proportional, as nearly as may be, to the population of that state (with the proviso that each state shall have at least one representative). There appears to be no dispute on this point. The only question is, *what method of computation comes nearest to satisfying this requirement of proportionality?* This is a purely mathematical question, important facts about which were not known until 1921. Certainly the "framers of the Constitution" had no idea of the mathematical pitfalls that surround the whole question; and any discussion of methods of apportionment which does not take account of the clarification introduced by the modern theory is futile.

It is particularly unfortunate that many influential statements that appear in the printed *Hearings* before the House Committee on the Census (February 21, 1928) as representing the opinion of a selected group of political scientists are directly at variance with known mathematical facts. These *Hearings* are constantly quoted in the congressional debates, and serious errors therein, if uncorrected, will be a source of confusion to future students of the problem, both in and out of Congress.[3]

[2] In regard to the method of major fractions, on the other hand, the modern theory has shown that this method can not be properly understood except in conjunction with a precisely analogous method known as the method of the harmonic mean (*Transactions,* p. 91). The method of major fractions has a distinct bias in favor of the larger states, while the method of the harmonic mean has a similar bias in favor of the smaller states. Between these two methods stands the method of equal proportions, which has been mathematically shown to have no bias in favor of either the larger or the smaller states.

way of satisfying the constitutional requirement of proportionality between representatives and population among the several states.

[3] For example, on page 63 we find the following statement, which is intended to show that the method of equal proportions is unduly favorable to the smaller states: "Inevitably, inherently, in the method of equal proportions, the average population of a congressional district in a group of small states is less than the average population of a congressional district in the very large states." This statement (which would be important if true) is mathematically false, as can readily be proved by numerical examples (*Transactions,* p. 95, Ex. 3, or p. 103, Ex. 11). Again, the new method of minimum range, which was suggested to the committee by Professor Willcox (*Hearings,* pp. 61, 76, 77) and was actually incorporated in a bill (H. R. 10883, February 13, 1928), has brought much confusion into the debate. The process of computation described for this method does not satisfy the test set up; and the test itself involves the defect known as the Alabama paradox. (A numerical example to show this, is the apportionment of sixteen or seventeen representatives among three states with populations 726, 539 and 335.) It should be noted also that in the able discussion on pages 91 and 93 of the *Hearings* the term method of minimum range is inadvertently used where the term method of the harmonic mean is intended. Again, the description of the method of equal proportions given on pages 61 and 62 of the *Hearings* is wholly wrong (see SCIENCE, May 18 and June 8), and the alternative test proposed on pages 62, 67, 77, 79, 88, etc., is mathematically ambiguous and hence unworkable (*Transactions,* p. 96, Ex. 7). The explicit statement on page 88, claiming that the method of major fractions is the only one which "makes the average population of congressional districts in small, medium, and large states as nearly as Congress can make it the same," is mathematically erroneous, as can be shown by well-known examples (*Transactions,* p. 92). In fact, one of the main objections to the method of major fractions is that it fails to equalize, in any sense whatever, the congressional districts in the several states.

The appearance of such misstatements as these in a permanent public document gives Congress a discouraging idea of the value of scientific methods. However widely scholars may differ on political questions they surely should be able to present a united front on questions of arithmetic. In the presence of this apparent conflict of opinion, *it would seem appropriate for any member of Congress to request a report on the mathematical facts from the National Academy of Sciences*—which is the body legally appointed to advise Congress on all scientific questions. The modern analysis has given a complete list of all the methods which might be said to satisfy, in any sense, the constitutional requirement of proportionality. Congress, and Congress alone, must make the choice between these possible methods; but all congressmen are desirous of having accurate information on which an intelligent choice can be based; and an authoritative report from the National Academy of Sciences would provide exactly this information, without in any way limiting freedom of action.

EDWARD V. HUNTINGTON
HARVARD UNIVERSITY

SCIENTIFIC EVENTS

PROJECT FOR AN ALEUTIAN GEOGRAPHIC OBSERVATORY

DR. T. A. JAGGAR writes in the *Volcano Letter* issued weekly by the Hawaiian Volcano Research Association on September 7, that he addressed the Seattle Chamber of Commerce on a proposed Aleutian Geographic Observatory to be established at Dutch Harbor, Alaska. It is estimated that to carry out this project the sum of $50,000 will be needed for equipment and that the upkeep will amount to an annual expenditure of $50,000. Dr. Jaggar stated that:

Experience shows that mapping should be the main aim, and that all sciences should be represented. The founding of the Hawaii Observatory by the sugar and other industries through the Volcano Research Association, with government collaboration, suggests that the fish, fur and shipping industries might do something effective for southwest Alaska.

Modern exploration and discovery are extended by each new invention. Montana and Arizona have been "discovered" to be garden spots through irrigation and agricultural machines. The *Carnegie* is mapping all the oceans with echo sounding and new electrical instruments.

The advent of the salmon canneries, of Diesel engines in 60-foot boats of 2,000 miles fuel radius, of radio communication, and of some new maps, have greatly improved the Alaskan field for the explorer.

It is proposed that the observatory be at Dutch Harbor as a fixed home for land and sea mapping and for measuring geophysical, biological and chemical processes along the arc of the Alaskan peninsula and the Aleutian Islands. The station will work in concert with eight scientific bureaus of the government, seven civil officers, and two outside institutions. It is called geographic, because it will study that part of the earth in relation to man.

It will measure and secure data all the year around concerning the weather, tides, currents, magnetism, earthquakes, volcanic activity, crust upheaval, animals, plants, fish, natives and commercial needs.

For the summer half of the year, the observatory will maintain expeditions to collect land and marine organisms, minerals, rocks and human antiquities; to map the lands, the geology, the depths of the sea, the air currents, temperatures and pressures, and such earth activities as magnetism, tremor, tilting and changes of mean sea-level. The snowy craters of the big volcanoes will be explored and photographed with the aid of alpinists and aviators.

There has come recently a demand for scientific study of the Aleutian lands from numerous scientific institutions and conventions, so that the matter is being pressed by the National Research Council of the United States. The writer has reconnoitered the field by three expeditions devoted primarily to volcanology.

The proposal is to place four workers at the main station winter and summer, equipped with a powerful Diesel yacht and small boats, also laboratories, shop, quarters, dock and photographic dark room. The station will keep in radio communication with its yacht and with existing stations. It will provide a base and a boat for the Coast Survey and the Geological Survey in mapping the coasts and interiors. It will publish weekly and quarterly reports.

The substations will work from April to September. The summer staff will be eight persons, and the substation will report to the main station. The substation camp will be left for future use. Specialists in all sciences will be imported from outside institutions for work at the substations.

THE CONTROL OF MALARIA

THE work that has been done in recent years for the prevention of malaria was described at a meeting held in connection with the Ross Institute for Tropical Diseases in the council room of the Rubber Growers' Association. Sir Malcolm Watson said, according to an account given in the *Journal* of the American Medical Association, that the medical profession, in a resolution passed at the congress of the Far Eastern Association of Tropical Medicine held at Calcutta in December, 1927, laid down a policy on the subject of malaria control. They considered that for towns, mines, plantations, large public works and similar aggregations of people the control of the breeding places of the malaria-carrying species of mosquitoes should be employed, whatever other antimalarial measures were put into force. Before effect could be given to