necessary to raise steam is wasted so far as the work to be done is concerned. Moreover, a steam engine requires continuous feeding of coal and close attention, so that a man must be always near it, having no other duties but its care.

In the natural-gas regions a large number of gas engines are working, and in the oil regions a similar number of oil engines and gasoline engines, because the nearness to the supply makes the fuel cheaper than transported fuel, and the exploding engine is more efficient than the steam engine.

It thus appears that in spite of the fact that the fuel element in the cost of power is high for engines burning crude oil, kerosene, and gasoline in comparison with those using coal, at the same time they possess advantages that do not exist in steam plants and gas-producer plants, which give them a very distinct field, as indicated by the following uses to which these engines are being put to-day: Driving boats, automobiles, and railroad motor cars; pumping water for private houses, for farms, for irrigation, and in some cases for municipal service in small towns; compressing air for drilling, hoisting, riveting, etc.; operating small carpenter shops, machine shops, forge shops, and, in fact, any kind of small shop; operating ventilating fans in buildings and in mines; running small factories, such as creameries and butter factories; operating feed-cutting and grinding machinery, corn shredders, and threshing machines; operating other special machines, such as ice-cream freezers, printing presses, mostly small in size, and making electric light in isolated localities. Not only is this field a real one, but it is a large one, as is shown by the number of these small engines being sold to-day. The exact figures on the sales are not available and it is impossible to secure them because of the unwillingness of manufacturers to tell their business; but when a single manufacturer (as is the case) is selling 425

of Brayton to use petroleum distillate came a series of inventions improving this class of engine, lasting for about twenty years, when the modern forms of kerosene, gasoline, and crude-oil engines may be said to have been developed. During this time the subject of alcohol as fuel in engines seems to have been either not thought of at all or not given any attention. The first serious attempt to examine into the possibility of alcohol as a fuel in competition with petroleum and its distillates seems to have been made in the year 1894 in Leipzig, Germany, by Prof. Hartmann for the Deutschen Landwirtschafts-Gesellschaft. The engine used was built by Grobb, of Leipzig, to operate on kerosene, and used 425 grammes of kerosene per hour per brake horse-power, which is equivalent to 0.935 pound, or 1.1 pints, approximately. This indicates for the kerosene a thermal efficiency of 13.6 per cent. When operating on alcohol the engine used about twice as much, or 839 grammes, which with this kind of alcohol was equivalent to a thermal efficiency of 12.2 per cent, or a little less than with kerosene. This experiment would seem to indicate that, compared with kerosene, alcohol, as a fuel, offered very little chance for successful competition. In spite of this, however, very vigorous efforts were made to develop an alcohol engine that would be better than this one, and thus was inaugurated a remarkable series of experiments, congresses, and exhibitions with the one end in view—of stimulating the production of the best possible alcohol motor.

The first stimulus was given by the German alcohol distillers, who sought to enlarge their market. They succeeded in interesting the German government in the question by enlarging on the national significance of having available a source of fuel for power, inexhaustible in quantity, to be produced within the national domain from the yearly crops. Under the double stimulus of government assistance and the desire of

understood, however, in interpreting these figures that they are the best possible attainable at the time reported. They indicate, so far as the fuel costs are concerned, that with a motor specially constructed for alcohol the fuel prices per gallon might be twice as much for alcohol as for petroleum distillate and still give power for less money, assuming that attendance, repairs, lubrication, etc., cost no more in the case of the alcohol engine.

The Office of Experiment Stations of this Department, in connection with its Irrigation and Drainage Investigations, has tested a number of different types of gasoline engines with alcohol and obtained figures which show the comparative consumption of gasoline and alcohol in the same engine. The detailed results of these tests will be published in a technical bulletin, but the general results may be given here. The first tests were made without any particular attempt at obtaining the best adjustment of the engine for each fuel, and showed a consumption of alcohol two to three times as great by weight per horse-power hour as was necessary with gasoline or kerosene. These figures indicate the necessity or desirability of determining the proper conditions of adjustment, because these were found to have a serious influence on the amount of fuel consumed. With care in adjusting the engine so as to secure the most economical use of the alcohol, it was found that, under like conditions, a small engine consumed 1.23 pounds of alcohol to 0.69 pound of gasoline per brake horse-power hour—that is to say, with the best adjustment of the engine for each fuel there was required 1.8 times as much alcohol by weight as gasoline per brake horse-power hour. It was also shown in making this adjustment that it was possible to burn more than twice as much alcohol as stated, by improper adjustments, and still have the engine working in an apparently satisfactory way. The range of excess gasoline which might be burned without interfering seriously with the working of the engine was not so great, being a little less than twice as much as the minimum. These early experiments, therefore, confirmed the early results secured in Germany, to wit, that an engine built for gasoline or kerosene will, when unchanged, require about twice as much alcohol by weight for the same work; but they also indicate something that is not pointed out by the reports sent us from abroad—that is, the great importance of securing the best adjustment of the machine.

To understand why this adjustment of the machine can have such a serious effect and at the same time understand why exploitation and study were successful abroad in raising the efficiency of the alcohol engine from 12.2 to over 30 per cent in five or six years requires a knowledge of technology. The reasons can only become clear to one understanding the mechanism of these engines and to one familiar with the chemistry of the fuels and the physical theories of explosive combustion.

(To be continued.)

[Concluded from SUPPLEMENT No. 1633, page 26160.]

RATE OF RECESSION OF NIAGARA FALLS.—II.

By G. K. GILBERT.
THE AMERICAN FALL.

THE recession of the American Fall is much slower than that of the Horseshoe. The sheet of water on its brink is comparatively thin, and the force the water acquires in falling is not sufficient to remove the larger of the limestone blocks broken from the ledge above. The blocks are therefore heaped at the base of the cliff and serve as a natural riprap to protect the shale against wear. (See Figs 18 and 19.) Since the Horseshoe Fall parted from the American, leaving it stranded at the side of the gorge, there has evidently been some falling away of the crest of the American Fall, else there would be no limestone blocks at its base. But as the talus increases in height it becomes more and more protective, and the rate of recession should theoretically diminish.

It has already been observed that the geologist's interest in the rate of recession applies primarily to the Horseshoe Fall, because the work of that fall makes the gorge longer. If the conditions of erosion had been uniform during the whole period of the excavation of the gorge the work of the American Fall would have little bearing on its time estimates, but the volume of the river has not always been so great as at present, and there were two epochs in the history of the gorge when the volume was very small. During those epochs the discharge of the whole river was probably not much greater than the present discharge through the American channel, so that the conditions affecting erosion were somewhat similar to those illustrated by the American Fall. For this reason it is worth while to inquire at what rate the American Fall has receded since the first precise observations on its position and contour.

Traditional information as to changes in the American Fall is summarized by Lyell:

"The sudden descent of huge rocky fragments of the undermined limestone at the Horseshoe Fall, in 1828, and another at the American Fall, in 1818, are said to have shaken the adjacent country like an earthquake. According to the statement of our guide in 1841, Samuel Hooker, an indentation of about forty feet has been produced in the middle of the ledge of limestone at the lesser fall since the year 1815, so that it has begun to assume the shape of a crescent, while within the same period the Horseshoe Fall has been altered so as less to deserve its name."

The graphic record begins with two camera lucida

Cost of energy in fuels.

Kind of fuel.	Cost of fuel.	British thermal units (B. T. U.).	Number of B. T. U. bought for \$1.
Small anthracite	\$2.50 per ton	12,500 per pound	10,000,000
Large anthracite	6.25 per ton	14,000 per pound	4,500,000
Illuminating gas	1.00 per 1,000 cubic feet ..	550 per cubic foot ..	550,000
Natural gas	.10 per 1,000 cubic feet ..	1,000 per cubic foot ..	10,000,000
Crude oil	.04 per gallon	20,000 per pound	3,650,000
Kerosene	.10 per gallon	20,000 per pound	1,200,000
Do.	.30 per gallon	20,000 per pound	400,000
Gasoline	.10 per gallon	20,000 per pound	1,200,000
Do.	.30 per gallon	20,000 per pound	400,000
Grain alcohol	.30 per gallon	12,000 per pound	270,000
Do.	.40 per gallon	12,000 per pound	200,000

Fuel cost of power.

Fuel and type of plant.	Fuel required per horsepower per hour.	British thermal units required per horsepower hour.	Thermal efficiency.	Cost of fuel.	Cost of fuel per horsepower per hour.
Anthracite coal:			Per cent.		Cents.
Large steam plant:	2 pounds	25,000	10	\$2.50 per ton	0.25
Do.	2 pounds	25,000	10	6.25 per ton	.57
Small steam plant:	7 pounds	100,000	21	2.50 per ton	1.00
Do.	7 pounds	100,000	21	6.25 per ton	2.20
Producer gas plant:	14 pounds	14,000	18	2.50 per ton	.14
Do.	14 pounds	14,000	18	6.25 per ton	.31
Do.	2 pounds	25,000	10	2.50 per ton	.25
Do.	2 pounds	25,000	10	6.25 per ton	.57
Illuminating gas:	24 cubic feet	12,000	20	1.00 per 1,000 cubic feet ..	2.20
Crude oil	1.4 pints	25,000	10	.04 per gallon	.68
Gasoline	1.1 pints	13,400	19	.15 per gallon	1.70
Do.	1.1 pints	13,400	19	.30 per gallon	3.40
Alcohol	1.1 pints	13,400	19	.30 per gallon	5.00
Do.	1.1 pints	13,400	19	.40 per gallon	6.70.

* Efficiency of alcohol is assumed to be the same as that of gasoline for identical conditions of use.

per day, and there are in the United States alone some 300 manufacturers of importance, there can be no doubt as to the popularity of these machines.

Alcohol at a price unknown now becomes available for use in engines, whose peculiarities are not fully known and whose ability to transform heat into work is correspondingly in question. If the alcohol engine can be shown to have an efficiency as high or higher than other liquid-fuel engines and be similar in type and characteristics, it can do all that they can do, and its field will be the same as their field in spite of fuel cost; but by field is meant the nature of the work rather than the geographical location. It is likely that the alcohol engine will find as favorable a geographical location as the natural-gas engine and the oil engine have near the source of supply and far from the source of competing supply. But should it appear that the alcohol engine can do more or better work than its oil or gasoline competitors, its field will be wider. In any case the position which the alcohol engine may take to-day is no criterion as to its future, because it will operate on a source of energy or fuel supply which, as pointed out, is inexhaustible, whereas the supply of both crude oil and its distillates may ultimately become exhausted.

The determination, then, of the position of the alcohol engine to-day involves a forecast of the future, and should it be shown to be able to compete now it must inevitably reach a stronger and more important industrial position as time goes on. This is the fact that has led governments to take up the question, and among them the United States is the latest.

FIRST USE OF ALCOHOL ENGINES.

About the year 1876 there was placed on the American market the first successful internal-combustion engine using petroleum distillate. This engine was invented by George Brayton. Following the attempt

the distillers to increase their output, inventors and manufacturers were induced to spend their time and money with a resulting decided improvement in the motor. An engine built by Körting Brothers, of Hanover, fitted with a vaporizer invented by Petreano, tested at the Polytechnic School at Charlottenburg by Prof. Slaby showed a consumption of 550 grammes of 86.2 per cent alcohol by weight, which is equivalent to 1.21 pound, or 1.4 pint, or a thermal efficiency of 17.5 per cent. This result showed an advance of nearly 50 per cent in thermal efficiency over the Grobb engine tested a year or so earlier by Prof. Hartmann. Following this improvement there resulted a continual development of the alcohol motor, interest in which was kept up by exhibitions in which prizes were offered and by scientific societies. The most important of these are given below:

Exhibition at Halle-on-Saal, Germany, June 13-18, 1901.

Exhibition (national) at Paris, France, November 16-24, 1901.

Exhibition at Berlin, Germany, February 8-16, 1902.

Exhibition (international) at Paris, France, May 24-June 1, 1902.

Exhibition at Madrid, Spain, late in the year 1902.

Congress at Montpellier, October 11-21, 1902.

Congress at Paris, France, March 11-17, 1902.

Exhibition (international) at Vienna, Austria, April 2-June 12, 1904.

Exhibition at Rome, Italy, February 6-16, 1904.

Besides the above named, there were many others of lesser importance, all contributing to the rapid development of this class of machine.

The results of this development may be summed up by saying that the thermal efficiency of the motor was raised to something over 30 per cent, which is quite a remarkable showing in comparison with the original figure of 12.2 per cent in 1894. It must be clearly

sketches by Basil Hall, made in 1827. One was from Goat Island, near the southern end of the crest line, the other from a point on the American shore near the northern end of the crest line. His view points were so near to the fall that he was able to represent details too small to appear in the sketch of the Horseshoe Fall. The American Fall was also mapped with the same care as the Horseshoe in 1842, 1875, 1886, 1890, and 1905. Since the time of the daguerreotype the fall has been photographed from positions similar to those occupied by Basil Hall, and in 1895 I recovered his view points as nearly as practicable for the

FIG. 10.—AMERICAN FALL IN 1827.

FIG. 11.—AMERICAN FALL IN 1895.

FIG. 12.—AMERICAN FALL IN 1827.

Copy of sketch by Capt. Basil Hall, with camera lucida, from American shore. The Horseshoe Fall is in the distance.
THE RATE OF RECESSION OF NIAGARA FALLS.

sake of making photographs which might be compared with his camera-lucida sketches. To this end I visited the localities with his sketches in hand, and endeavor-

it is shown that if the crest line in 1827 had had the form indicated by the map of 1842, its profile would have the position indicated by the dotted line A in

Fig. 10, and the cataract would conceal the eastern half of the gorge vista. If the great salient did not exist in 1827, it could not have existed in 1842. The

FIG. 13.—AMERICAN FALL IN 1895.

Photograph from Prospect Point, a few feet to the left of the view point of Fig. 12. Note that the American Fall has changed little and the Horseshoe Fall much.

ed to determine the view points by comparing various details of the sketches with the landscape before me. His sketches and the photographs are compared in Figs. 10, 11, 12, and 13.

Examination of the combined map (Fig. 4) shows that the outlines recorded in 1875, 1886, 1890, and 1905 run closely together, the plotted lines intersecting one another at various points, while the line of 1842 coincides for only a part of the distance. A broad projection near the northern shore is indicated by the map of 1842 only, and that map also gives a more advanced position for the middle part of the crest line.

There is good reason to question the accuracy of the map of 1842, especially in the vicinity of the northern shore. The area there indicated outside the line of 1875 and later maps is 110 feet broad. As its position is close to Prospect Point, which has been a popular view point through the entire period under consideration, the falling away of such a body of rock, either gradually or all at once, could not have escaped notice, but (so far as my reading goes) current literature, including the literature of the guidebooks, is silent in regard to it. In addition to this negative evidence, there is positive information in the Basil Hall sketches. Comparing his sketch from Goat Island (Fig. 10) with my photograph made from approximately the same point in 1895 (Fig. 11) it will be seen that there is essential correspondence in the distant headlands along the river. By means of these headlands I was enabled not only to establish a definite relation between the two views, but also to correlate the sketch of 1827 with the map of the gorge made in 1875; and by the aid of that map with the various charts of the crest line. Through these comparisons

FIG. 16.—THE AMERICAN FALL IN 1854 OR 1855.

From a daguerreotype. To be compared with Figs. 12 and 13, but the view point is farther to the left and nearer the water. Many details of the crest of the American Fall are the same as in 1895, but the details of the Horseshoe Fall and the cliff profile of Goat Island differ from those of 1827 and 1895.

FIG. 18.—AMERICAN FALL ABOUT 1885.

Shows talus of limestone blocks. Compare with Fig. 19, which represents the middle part of the fall.

THE RATE OF RECESSION OF NIAGARA FALLS.

work revealed three errors in the bearings as published, probably to be ascribed to copying or printing and not affecting the map. It indicated also that the points of the crest lines determined by intersection are not all accurately placed on the map, the errors amounting usually to a few feet, but not affecting the computed rate of recession.

Each of the crest-line points was originally located, as a rule, by the intersection of two bearings, but there are four points to which three bearings were taken. In the replotting of these points the check afforded by the third bearing was found to give a satisfactory result. The points which have the advantage of this check are all on the east side of the Horseshoe curve, and include the point at the angle of the Horseshoe in the position where the notch subsequently developed (Z in Fig. 6). For the remainder, or western part, of the Horseshoe curve there is no similar check, and the three located points of the crest line are so far apart as to give little mutual support. So far as the published data are concerned, these have no higher intrinsic authority than the two points on the American Fall which have been discredited by independent evidence.

The record of the Horseshoe Fall which stands nearest in time to the map of 1842 is Basil Hall's sketch from the Forsyth Hotel (Fig. 7), the interval being fifteen years. The general form of the crest line is the same in map and sketch, and the tangent based on the sketch is so related to the mapped crest line (Fig. 6) as to indicate some recession between the dates of the sketch and the map, but the amount of recession is less than would be expected.

The factors bearing on the estimate of the rate of recession are not so related that rigid mathematical methods can be applied to their discussion. The conflict of data and the mutual support of data can be weighed only by non-mathematical methods, and the result of their study is an opinion rather than a decision. The general tenor of the evidence, including the five surveys and the Basil Hall sketch, leaves no question that the annual rate of recession has been about 4 or 5 feet. If full authority be ascribed to the map of 1842, the estimated annual rate of recession is 5.3 feet. If full authority be ascribed to the tangent line based on the sketch of 1827, the estimated rate is about 1 foot less. It is my opinion that the map affords the better record. Giving to it the greater weight and to the tangent a smaller weight, I think the best practicable estimate of the rate is between 5.3 and 4.2 feet, but nearer to the former; and I select 5 feet partly because a statement in even feet avoids the implication of high precision which might be suggested by a decimal. As an estimate of the average rate of recession during the period of definite observation, I think this can not be in error more than 1 foot.

SUMMARY AND CONCLUSION.

The data for computing the rate of recession of Niagara Falls include surveys of the crest line made in 1842, 1875, 1886, 1890, and 1905, and camera lucida sketches made in 1827. During the period covered by these data the local conditions affecting the rate of recession have not differed to an important extent from the natural conditions. The present and prospective diversions of water for economic uses interfere with the course of nature and may be expected to modify the rate of recession. The natural rate of recession of the Horseshoe Fall is desired by geologists in connection with estimates of the age of the river. The geologic bearing of a rate modified by human agency is less direct. The rate of recession of the American Fall is of interest to geologists because somewhat representative of the river's activity in gorge making when the volume of water was much less.

The rate of recession of the Horseshoe Fall, or the rate of lengthening of the Niagara gorge, during the sixty-three years from 1842 to 1905 is found to be 5 feet per annum, with an uncertainty of 1 foot. For the thirty-three years from 1842 to 1875 the rate was apparently slower than for the thirty years from 1875 to 1905. The rate of recession of the American Fall during the seventy-eight years from 1827 to 1905 was less than 3 inches per annum.

The time consumed in the recession of the falls from the escarpment at Lewiston to their present position, or the age of the river, is not here estimated. It can not properly be computed without taking account of all conditions, local and temporary, affecting the rate of recession, and some of those conditions have varied greatly from point to point and from time to time.

AGNES MARY CLERKE.*

By E. A. DENT.

In the death of Agnes Mary Clerke, which took place on the 20th of January last, the scientific world lost one of its most useful and distinguished members.

Miss Clerke was one of the four eminent women upon whom, by virtue of scientific attainments, Fellowship in the Royal Astronomical Society has been conferred. The others were Miss Caroline Herschel, Mrs. Somerville, and Lady Huggins.

As a clear and forceful writer on astronomical subjects Miss Clerke was almost unrivaled. Her knowledge was deep and thorough; her outlook was broad, and her attitude as a student of the heavens fearless but reverent. Her original investigations covered many subjects, such as studies of star colors, star distribution, the classification of stellar spectra, variable stars, etc., but her great skill in compiling the results of the work of others, and her keen insight in comparing and discriminating as to the bearing and value of

different classes of evidence, almost overshadowed her own investigations. The value of her books is enhanced by their charming literary style, fluent yet dignified language, and general grace of expression. They are notable as works of literature as well as of science.

Agnes Mary Clerke, daughter of John William Clerke, was born in the County of Cork, Ireland, on the 10th of February, 1842. Though her astronomical reading began when she was a child of eleven years, her education was not designed to fit her for scientific work. In reply to a question of the writer on the subject she said:

"The truth is bare and bold enough in sound, that in the scientific sense I had no education, but just picked up what came my way. I had a childish passion for natural knowledge and read the books accessible to me in my father's library, taught myself with the minimum of assistance some elementary mathematics, and that was all. I was also very delicate growing up and never went to school, . . . but I had admirable instruction from private professors in languages and music. I had from time to time tried writing stories and poetry, with indifferent success; but in Italy I undertook more serious work and contributed on various topics to the *Edinburgh Review* from 1877. An article on 'The Chemistry of the Stars' made a turning point. The studies for it revived my astronomical tendencies; Messrs. Black accepted my proposal to write for them a history of recent astronomy, and so I went on."

The publication of "A Popular History of Astronomy in the Nineteenth Century," upon which she spent the work of four years, brought her at once to the attention of the scientific world. The book was at once recognized as a most important contribution to as-

Miss Clerke, (February 22, 1907), said: "No worker in the vast field of modern sidereal astronomy opened by the genius of Herschel and greatly advanced by the application of the spectroscope to the chemical and physical problems of the universe lacked due recognition by Miss Clerke, who performed as it seemed no other writer could have done the work of collation and interpretation of this enormous mass of new material, ever pointing the way to new fields of investigation, often by one pregnant suggestion sweeping aside a whole sheaf of tentative conjectures, and indicating, if not the true line—for in many cases the truth is yet to seek—at least a plausible and scientific line well worth pursuing. She will be missed at the meetings of the Royal Astronomical Society, at which she was a constant visitor, . . . where her clear judgment was at times called upon to determine the value of some new suggestion in the domain of celestial physics."

FORMS FOR CONCRETE CONSTRUCTION.*

By SANFORD E. THOMPSON, M. Am. Soc. C.E.

RECENT failures in reinforced concrete construction cannot be cast aside and forgotten with the passing comment so frequently heard, that the accident was due merely to poor construction or too early removal of forms. The reasons for every failure should be thoroughly investigated by experts to prevent recurrence of similar accidents.

"Poor construction" and "forms," although frequently guilty, are by no means the only culprits. Just so long as men who know nothing of the first principles of mechanics are permitted to design concrete structures, and just so long as irresponsible contractors are engaged to erect them, the list of accidents will in-

FIG. 1.—CENTER FOR 8 FOOT CONDUIT.

tronomical literature. It reached its fourth edition in 1902, and has been translated into German.

"The System of the Stars," published in 1888, contains the result of several months' work at the Cape Observatory, studying the southern heavens under the guidance of Sir David Gill. The second edition, published in 1905, is largely re-written, in view of the progress which had been made in astronomical research since its first appearance. The same remark may be made of the "History," which was not permitted to become out of date.

"Problems in Astrophysics," published in 1903, deals essentially with twentieth century astronomical science. It embodies not only a history of what has been accomplished in astrophysical research, but it suggests the directions of possible and probable advance and development, stimulating the worker to further investigation. The Fellowship in the Royal Astronomical Society which was conferred upon the appearance of this book was no doubt intended as a public recognition of the value of her services to astronomy.

"The Herschels and Modern Astronomy," published in 1895, is a short history of the celebrated family and its contributions to astronomical science.

Shorter works are "Familiar Studies in Homer," published in 1892; two sections of "Astronomy" in the Concise Knowledge Series; the "Hodgkins Essay" on Temperature Research at the Royal Institution, 1901; about one hundred sketches of the lives of scientific men for the Dictionary of National Biography, and many of the articles in the Encyclopædia Britannica upon the life and work of such men as Galileo, Kepler, Laplace, etc.

The last work, published a year ago, was "Modern Cosmogonies." It is a review of the theories of the universe which have been advanced from time to time, with a discussion as to their merits and defects.

The London Times, commenting on the death of

crease in startling numbers. It is the men—not the inanimate lumber—who are to blame in every case. However, granting its danger under ignorant hands, reinforced concrete as a whole must not be condemned for failures due to improper conditions any more than brick should be rejected as a building material for apartment houses because of the collapse of several unfinished buildings in New York city two years ago through disregard of frost action upon the mortar.

Failures in concrete buildings may be attributed to:

(1) Imperfect design; especially through neglect of essential details in locating the reinforcing metal, and through the adoption of too low a factor of safety.

(2) Poor materials; such as cement which does not properly set up, or sand which is too fine or which has an excess of clay, loam or other impurities.

(3) Faulty construction; from improper proportioning, mixing or placing, or too early removal of forms.

(4) Weak forms.

A disregard of such important principles is frequently criminal negligence, and yet in at least one case under my observation an examination of the structure and the materials after a collapse in which a number of lives were lost showed the design, materials and construction to be all so faulty that it was impossible to decide positively which of the four causes named above was the primary reason for the failure.

In this paper it is proposed to treat only of the design, construction and removal of forms.

GENERAL RULES FOR FORM CONSTRUCTION.

Kind of Lumber.—The selection of the lumber must be governed by the character of the work and the local market. White pine is best for fine facework, and quite essential for ornamental construction cast in wooden forms. For ordinary work, however, even for

* Journal of the Royal Astronomical Society of Canada.

* Paper read before the Third Convention of the National Association of Cement Users.