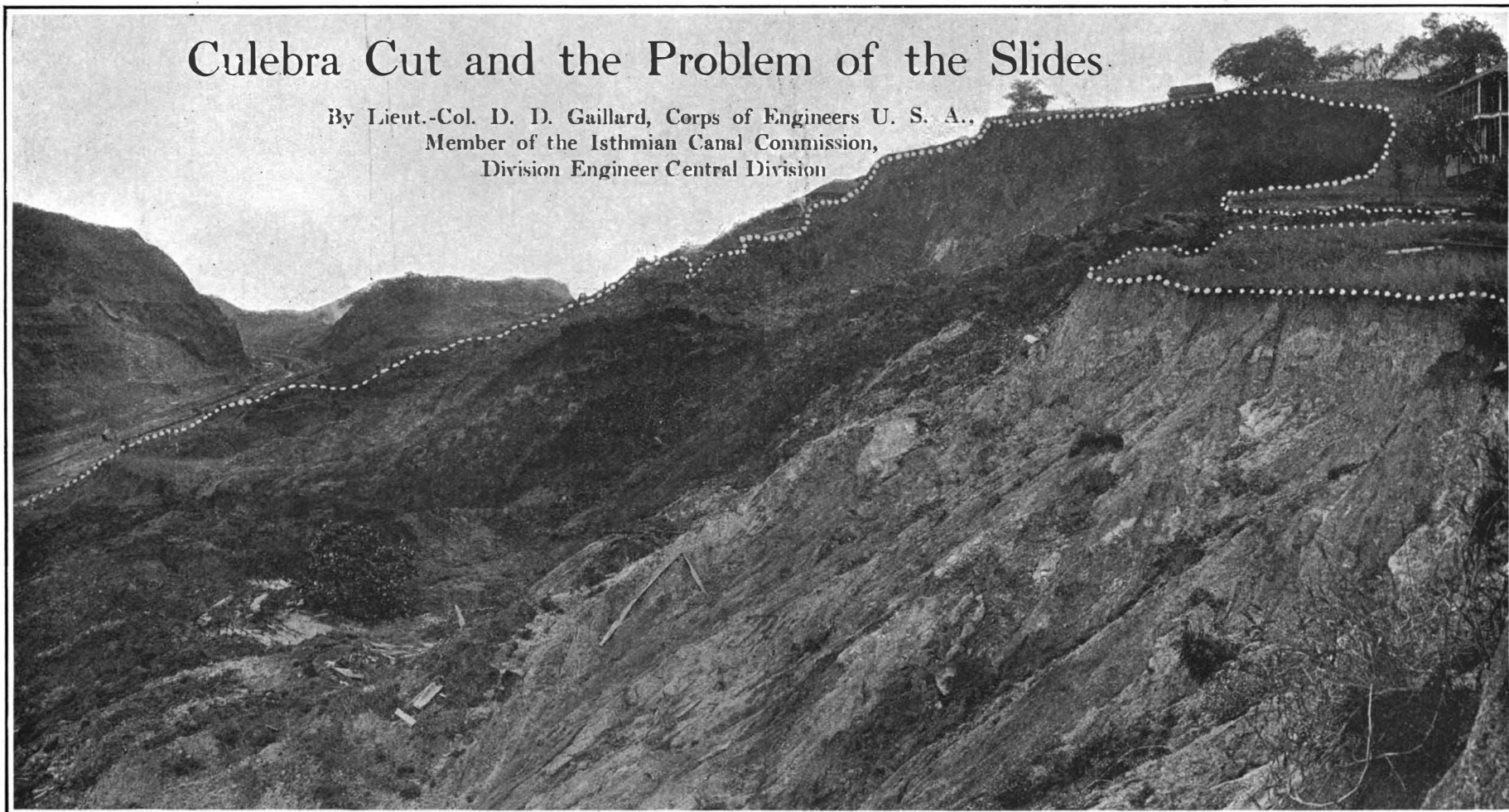


Culebra Cut and the Problem of the Slides

By Lieut.-Col. D. D. Gaillard, Corps of Engineers U. S. A.,
Member of the Isthmian Canal Commission,
Division Engineer Central Division



Slide on west bank of the cut, Culebra, September 27th, 1912, looking south toward Gold Hill. This slide occurred about August 25th, 1912, and involves about one and a quarter million cubic yards of moving material. It is composed wholly of clay and occurs where a natural pocket of this material existed.

THE Central Division, of which the writer has been in charge since April, 1907, extends from Gatun dam to Pedro Miguel locks, a distance of 31.7 miles, and embraces the entire summit level of the canal, the water surface of which is 85 feet above sea level.

For administrative purposes, the Central Division was divided into two parts, known as the Chagres section and the Culebra section—the latter being generally known as the Culebra cut. This section extends from the Chagres River at Gamboa to the Pedro Miguel locks, a total distance measured along the axis of the canal of 8.8 miles, and comprises the natural summit of the water shed which separates the Pacific Slope from the Caribbean Slope, and culminates in Gold Hill on the east bank of the canal and Contractor's Hill on the west bank. As a consequence, this comparatively short section embraces nearly one half of the total excavation required for the entire waterway between the Pacific Ocean and the Caribbean Sea.

Actual excavation on this section was commenced by the French in January, 1882. The plan under which the greater part of their work was carried out was for a sea level canal, 72.16 feet in width at the bottom and 27.9 feet in depth. Owing to financial and physical difficulties, this project was modified in 1887 to a lock canal with ten locks and with a summit level 160.7 feet above sea level, and, with the exception of the period between May, 1889 and October, 1894, work was carried on continuously in the Culebra cut, first by the "Old French Company" until it failed in 1889, and later by the "New French Company," with greatly diminished forces, until the United States assumed control in May, 1904.

From the commencement of operations by the French until the canal was acquired by the United States, a total of 24,588,520 cubic yards of material was excavated within the limits of the Culebra cut, of which 20,419,720 cubic yards form a part of the present approved project.

This project in the cut is for a canal with a minimum width of 300 feet on the bottom, a minimum depth of 45 feet and a width on the water surface of 309 feet. To secure these dimensions in the Culebra cut, it is now estimated that it will be necessary to excavate in all about 115,000,000 cubic

yards of material, including the useful French excavation, of which about three quarters is classified as rock.

When the United States acquired control of the canal in 1904, the entire force of laborers who had been working under the French Company, about six or seven hundred in number, were transferred to the United States' pay-rolls, thus preventing any actual cessation in the work of constructing the canal. This original force was increased from time to time until it attained its maximum in March, 1911, during which month the average daily working force in the Culebra cut, and on the dumps connected with it, was about 900 Americans and 7,300 European and West Indian laborers.

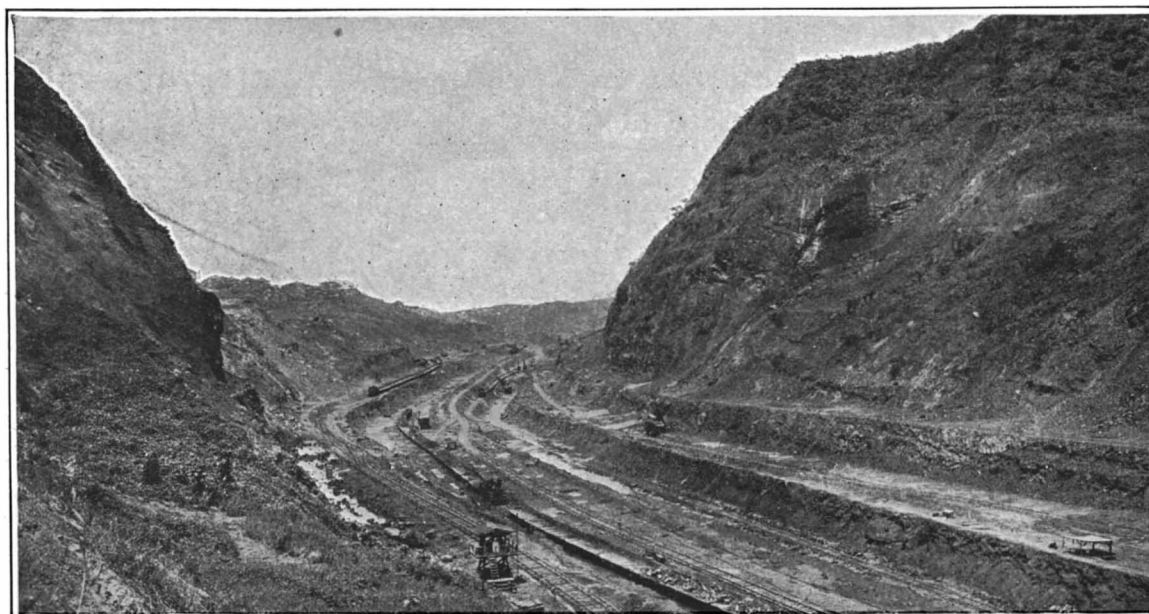
The engineering problems connected with the work are handled by the engineering force, under a resident engineer. In addition, there is a superintendent of transportation, who handles all transportation matters in the Central Division, and a superintendent of the water and air service, who sees that all shovels, drills, pumps, etc., are connected with water and air mains. That these positions are no sinecures may be inferred from the fact that in the one case over 1,000 loaded and empty trains have been handled in the Central Division in a nine-hour day, and in the other, an average of two miles of water and air pipe is laid and two miles taken up, for every working day in the year.

As most of the material to be excavated consists of

rock varying from very soft rock, which readily disintegrates on exposure to the atmosphere, to very dense rock of great hardness, it is necessary before this material can be excavated, that it be drilled and blasted. Two kinds of drills are used in this work—tripod drills and well drills, and both obtain their power from a 10-inch compressed air main on the west bank of the cut, running parallel with the same. This main is supplied by three batteries of air compressors located at equal distances along the ten miles of main. All excavation in the cut is done with steam shovels with 3-yard and 5-yard dippers, the latter being used almost entirely. The order of operation is as follows: Drill holes are placed normally about 14 feet apart and staggered. Their usual depth is about 27 feet, being three feet deeper than the depth to which the shovel excavation is to extend. When these holes have been completed, they are loaded with 45 per cent potassium nitrate dynamite, in suitable quantities, depending upon the character of the rock. A group of holes are connected "in parallel" and fired by means of a current from the electric lighting plant. The shovel then follows at a suitable distance and loads the material onto steel cars, which are dumped by hand, or on Lidgerwood trains, from which it is plowed off at the dumps by means of unloaders, and plows weighing from 14 to 16 tons.

The maximum number of drills in use at any time in the Culebra cut was 377, of which 221 were tripod drills and 156 were well drills. With these drills, an aggregate of over 90 miles of holes have been drilled in a single month. In blasting operations, a pound of dynamite is now used to about every $2\frac{1}{4}$ cubic yards of material blasted, and the quantity of dynamite used per annum in the Culebra cut for several years past has averaged about 6,000,000 pounds. The greatest number of shovels in use at one time in the cut was 43, and the greatest monthly excavation in any single month was obtained in March, 1911, when 1,728,748 cubic yards of material, mostly rock, were excavated.

To handle this amount of material required the services of 115 locomotives and 2,000 cars, giving about 160 loaded trains per day to the dumps, which on the average were



View showing point of deepest excavation in Culebra cut, September 30th, 1912. Gold Hill on the right, where highest point of excavation will be 494 feet above the bottom. Contractor's Hill on the left, where highest point of excavation will be 364 feet above the bottom. The water standing in the lowest level is 6 feet above the bottom.

about 12 miles distant, the haul one way varying, however, from about one mile to 33 miles. To serve properly the trains and shovels employed in excavation work in the cut, although the latter is less than nine miles in length, about 100 miles of track are required, or an average of over nine parallel tracks at all points of the cut.

The deepest excavation is at Gold Hill, where the highest point of excavation is 494 feet above the bottom of the canal. At Contractor's Hill, a cut 364 feet in depth will be made in the face of the rock hill. The widest part of the cut is opposite the town of Culebra, where owing to the action of slides on both banks, the top width is now about half a mile.

In the earlier stages of the work, accidents resulting from the use of dynamite were unfortunately not uncommon, and one of the first steps taken was to require a strict inspection of the handling of dynamite and the loading and firing of holes. In spite of every precaution, it was found impossible to avoid a considerable number of miss-fires, and a study was made, with the assistance of the electrical and mechanical engineer, with a view of endeavoring to locate definitely the cause of these miss-fires.

As a result of a long series of experiments, it was conclusively shown that by far the greater number of miss-fires were due to the fact that the holes had been wired "in series." When the fuses were connected "in parallel" and fired by means of the ordinary electric light current, not a single failure of a fuse was noted in a test comprising several hundred fuses.

The results of this investigation were so convincing that all holes are now wired "in parallel" and miss-fires have been almost wholly eliminated, although it is scarcely necessary to state that accidents from individual carelessness, from flying stones, or from other causes, will always occur in the extensive use of dynamite, no matter what precautions may be adopted. It is, however, gratifying to state that although during the past three and one quarter years, in work under the writer's charge over 20,000,000 pounds of dynamite were used in blasting, but eight men have been killed, three of whom failed to go to a safe distance and were killed by flying stones, and two by miscounting the number of shots which had gone off in a "dobe" group, and approaching the group before the last shot had exploded.

Then, too, the character of the material to be blasted is of such a nature that slides and slips are of constant occurrence, rendering the use of explosives more hazardous than in ordinary localities. In addition, ever since the work of excavation has been commenced in the Culebra cut, areas have been uncovered where, owing to the presence of iron pyrites in finely divided form, the material on exposure to air generates, by oxidation, a sufficient degree of heat to fire dynamite when placed in the drill holes, and on two occasions dynamite has been so fired, but fortunately, without loss of life. As the heated layers may lie at any distance below the surface of the ground, and are usually rather limited in thickness, it is impossible from external observation to detect the heated holes by inspection, and in cases where danger from heating is apprehended, an iron pipe $\frac{3}{4}$ inch in diameter is

dropped into the hole and allowed to stay there about ten minutes. On being taken out and passed rapidly through the hand, it can readily and accurately be determined whether or not there is a heated layer of material in the hole, and if so, where it is located. On one occasion, a mass of heated material was encountered, which it was necessary to blast and remove with as little delay as practicable, and this was safely done by playing a stream of water from a hose into the holes during the entire process of loading and until the holes were fired.

The total amount of material excavated from the Culebra cut to date is as follows: By the French,

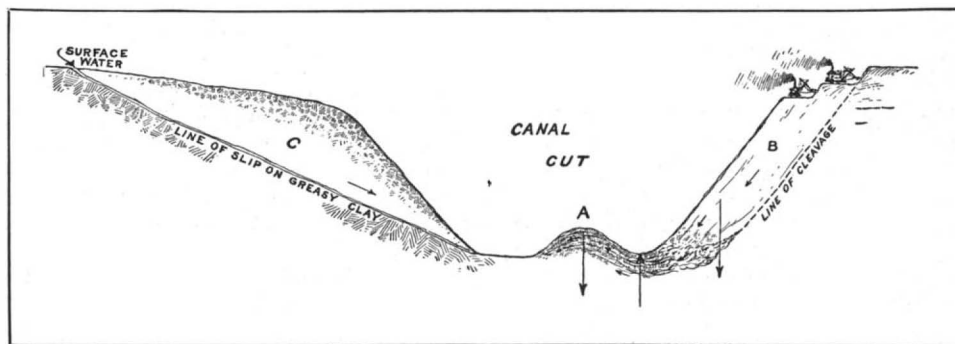


Diagram showing the action of slides in the Culebra cut. The mass C is moving into the cut by sliding; the mass B breaks on a line of cleavage and crushes the underlying material, forcing it up at A as shown. Note steam shovels taking off top weight from B.

prior to May, 1904, 20,419,720 cubic yards. By the United States, May, 1904, to October 1st, 1912, 85,370,236 cubic yards. Amount remaining to be excavated, October 1st, 1912, 9,250,000 cubic yards.

Parallel with the Culebra cut and on each side of it diversion ditches or canals were constructed in order to keep the waters from the drainage areas on the two sides of the cut from flowing into the latter and interfering seriously with or preventing excavation during the rainy season. The diversion ditch on the west side of the canal is known as the Camacho diversion, and is about $5\frac{1}{2}$ miles in length, extending from Culebra to the Chagres River. This diversion has a capacity,

at its mouth, of 3,000 cubic feet per second and was constructed by the French. On the east side of the cut, between Gold Hill and the Chagres River, for a distance of $5\frac{1}{4}$ miles, extends the Obispo diversion, which drains an area of nearly 10 square miles, having an average annual rainfall of about 83 inches, most of which occurs in eight months of the year. Its construction has cost up to date about \$1,250,000—a large sum, yet without its protection, the canal could not have been completed. This diversion has been constructed since the United States assumed control. The third diversion, known as the Rio Grande diversion, extends from Rio Grande to Pedro Miguel, a distance of about three miles, and was constructed by the French. The large and annoying Cucaracha slide on the east side of the canal, between Gold Hill and Pedro Miguel, prevented the construction of a diversion along that portion of the Culebra cut.

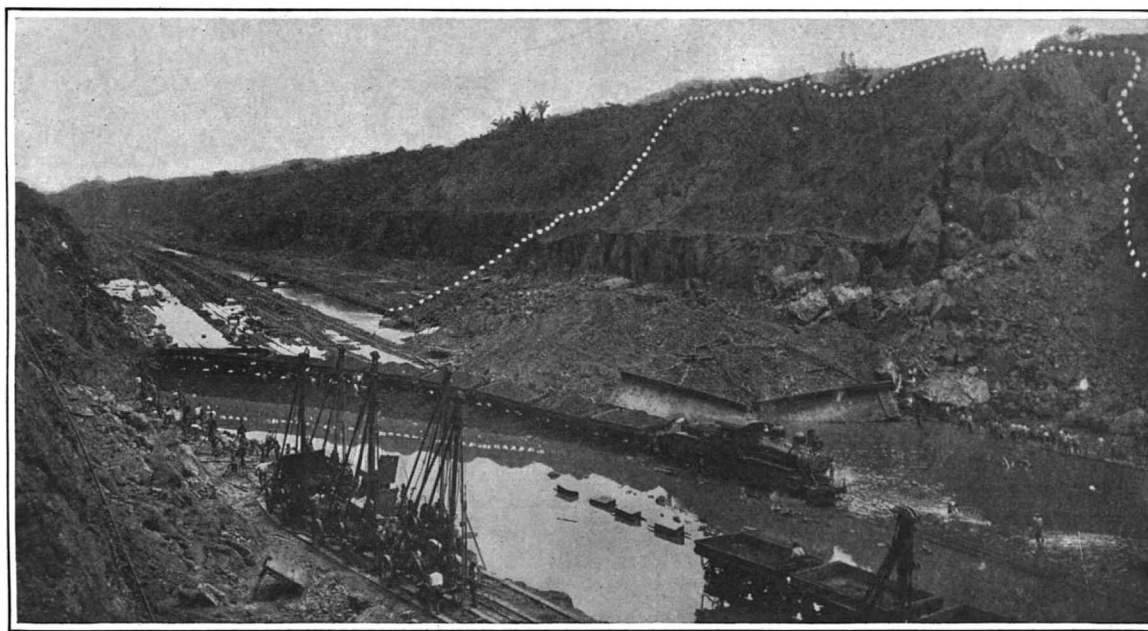
The Problem of the Slides.

During the early stages of the work by the United States, there was but little movement of material into the canal from outside of the prism, and when such movement began, it was due almost entirely to slides caused by the slipping of the top layer of clay or earth upon a smooth sloping surface of some harder material, the layer of slipping clay in such cases varying in thickness from 10 to 40 feet.

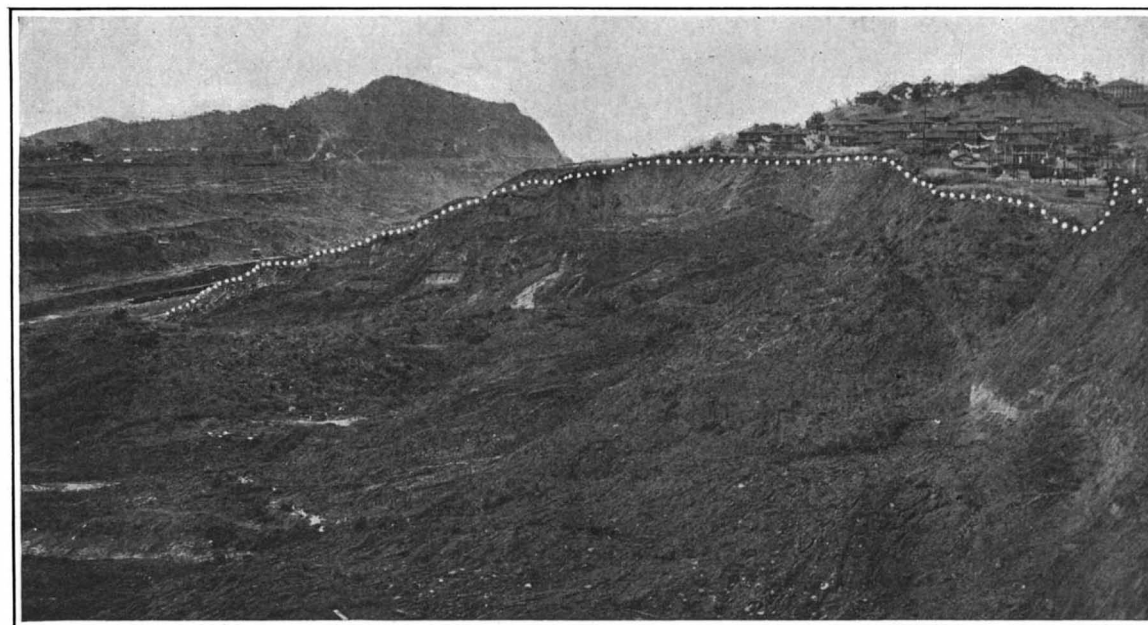
The largest slide of this character is the Cucaracha slide on the east bank of the canal, just south of Gold Hill, which embraces a total area of over forty-seven acres. This slide extends up the bank for a distance of over 1,900 feet from the axis of the canal, and originally had a slope of about one vertical to seven horizontal. It first began to give serious trouble in the fall of 1907, and moved completely across the canal, the toe of the slide advancing for the first ten days at a uniform rate of about 14 feet in twenty-four hours. All tracks in its path were covered or destroyed by its resistless motion, and the moving material actually rose up on the west bank to a height of about 30 feet. Its movement was singularly like that of a glacier. It was, in fact, a tropical glacier—of mud instead of ice—and stakes aligned on its moving surface and checked every 24 hours by triangulation, showed a movement in every respect similar to stakes on moving glaciers in Alaska upon which the writer had made observations in 1896.

Up to July 1st, 1912, nearly 3,000,000 cubic yards had been removed from this slide, and it was estimated that about 230,000 cubic yards yet remained to be removed.

As the depth of the cut increased and the lateral support formerly afforded by the excavated material was removed, the great pressure of the superincumbent banks caused the crushing and squeezing out of underlying layers of soft material, with a breaking, shearing and settling of the high banks and a corresponding elevation or "humping" of the bottom. (See diagram showing action of slides.) For the past two or three years, slides or breaks of this character have greatly exceeded those of the type represented by the Cucaracha slide. The largest slide of the type just described is on the west bank of the canal at Culebra, and covers an area of 75 acres. Up to October 1st, 1912, over 7,500,000 cubic yards of material had been removed from this slide and fully 2,000,000 cubic yards remained still to be removed. The



Slide in rock bank, side of cut north of Empire, which occurred August 20th, 1912. About 400,000 cubic yards of rocks slipped into the cut, destroying tracks, wrecking cars, and permitting the waters of the Obispo Diversion to flow into the cut.



Slide at Culebra on the dump, west bank of canal, north of Culebra. About 1,000,000 cubic yards of material in motion moving toward the cut at the rate of three feet per day on a bottom slope of about one vertical to seven horizontal. June, 1912.

only remedy for slides of the first class has been to dig and haul away all of the material involved in the slide. With slides or breaks of the second class, a like course is pursued for banks already broken; but with slides of the latter class, preventive measures as well are taken. These preventive measures consist in flattening the slope of the bank where breaks might be expected by excavating and removing the upper portion of the banks by steam shovels, thus decreasing the pressure which might otherwise crush underlying layers of softer material and cause the bottom to heave up. This lightening of the superincumbent weight of the adjacent banks in the deeper portions of the cut by flattening the slope, has given results sufficiently encouraging to warrant the continuance of this work until all excavation has been completed and the full depth and width have been obtained.

With a few exceptions, the so-called slides during the past year were in reality breaks in the bank, resulting from the crushing of an underlying layer due to the great pressure of the high banks, the underlying layer being displaced laterally, and causing a heaving up of the bottom, amounting in one instance to as much as 30 feet.

On one occasion the writer was standing on a portion of the bottom of the cut, which rose six feet in about five minutes, and moved so smoothly and with so little jar as to make the movement scarcely appreciable, it being his impression at first that the steam shovel which he was observing was sinking and not that he was rising.

Innumerable plans for treating the slides have been suggested by interested and patriotic citizens throughout the country, but not one of them has proven practicable. The only successful method of treating the slides or breaks, once the material is in motion, is

clouds of dust. One of these slides was moving on a surface which had a slope of one vertical to six horizontal, and its rate of advance was about $2\frac{1}{2}$ feet per day for several months. A steam shovel made 103 cuts across the toe of this slide with the position of the loading track unchanged.

From the commencement of operations up to October 1st, 1912, there had been excavated and removed, about 18,000,000 cubic yards of material from slides, aggregating an area of about 220 acres, and there probably remain yet to be excavated on account of slides at least three or four million cubic yards more.

As the result of several years experience, slides and breaks are now handled with less inconvenience and interruption to other work than was the case in the earlier stages of operations. Yet, notwithstanding increased efficiency in handling them, they cause continual annoyance and interruption to work, and decrease the output and complicate the engineering problems; and while they present no insurmountable obstacles to the completion of the work in the Culebra cut, yet they are ever-present sources of annoyance, hindrance and expense. Their effects are especially felt in the destruction, displacement or covering up of tracks, requiring large track gangs to be kept continually at work in their vicinity.

A conservative estimate indicates that within the 8.8 miles of the Culebra cut, fully 200 miles of track have been destroyed, covered up or have had to be built, solely on account of slides; and in one locality for nearly two years tracks have had to be maintained on material moving at a rate varying from one or two inches to several feet per day, necessitating the constant presence of a track gang in order to permit the uninterrupted passage of trains.

It will be seen from what precedes that when the

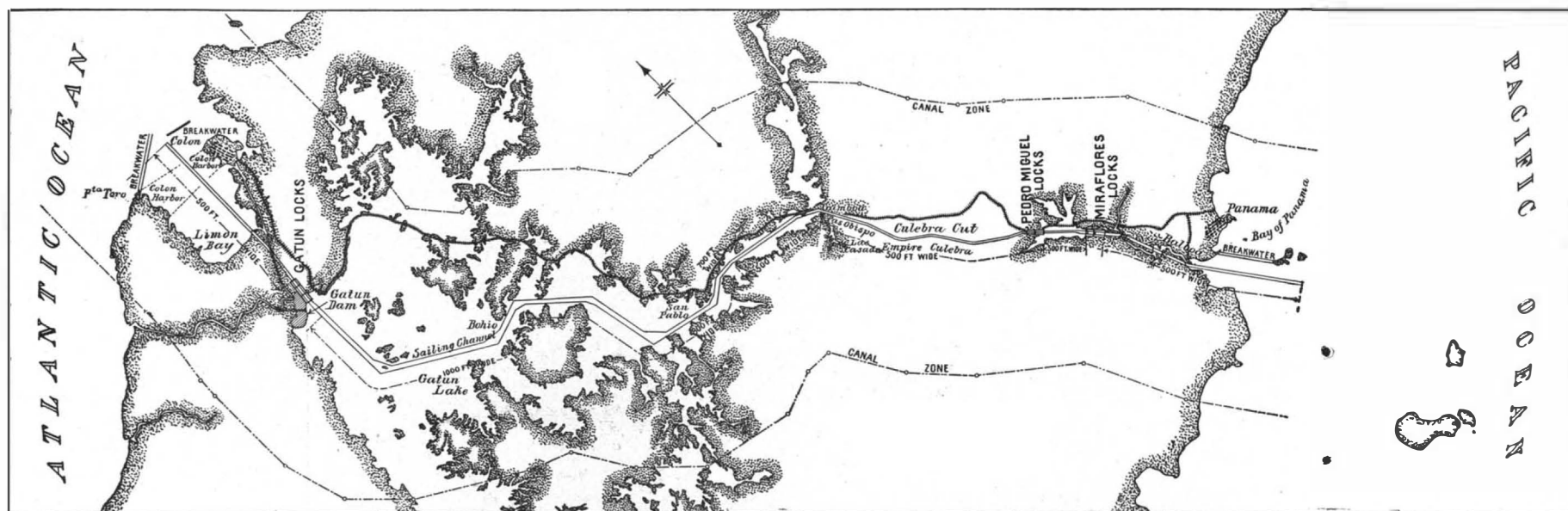
in the original estimate, it seems probable that there will still remain from the estimate of September 1st, 1908, an ample surplus of funds for completing the work in the Central Division without additional appropriation.

So far as the time of completion of excavation in the Culebra cut is concerned, in spite of the large additions by slides, the work is still well up to the original schedule, and had there been no slides, would have been completed with ease in January, 1912; an amount of material equivalent to the total excavation, exclusive of slides, having been removed by that time. In reality, however, it would have been completed sooner, as slides have decreased the average monthly output in addition to adding a large surplus of material.

The Greatest Engineering Work of All Time

IN conveying ideas of size and quantity to the mind there is a point at which the use of figures—mere figures—becomes altogether inadequate. When statistics run into the millions, the mind, unless it is assisted by some more or less concrete scale of measurement, fails to form an adequate conception of what they mean. That this is particularly true of the great engineering work which is now drawing to a close on the Isthmus of Panama is proved at once by a glance at the pictorial representation on the adjoining page—a method of illustration with which our readers have been made familiar during the past few years in the columns of the SCIENTIFIC AMERICAN.

Alike in times ancient, medieval and modern, the great pyramid of Egypt (one of the "seven wonders" of the Ancient World) has been taken as the standard of measurement for engineering and architectural structures of exceptional proportions. Now, when the engineers of the canal tell us that the total amount of



Map of the Panama Canal.

to dig it out and haul it away until the slide comes to rest upon reaching the angle of repose for the particular material then in motion. This angle of repose varies much in different localities, depending upon the character of the material composing the slide, the angle of inclination of the strata and the angles of the numerous dikes, faults, seams, etc. At the Cucaracha slide, which has been practically at rest now for about a year and a half, the angle of repose corresponds to a slope a little steeper than one vertical to five horizontal, while on the west bank of the cut at the town of Culebra, the material is still moving slightly on a slope of about one vertical to five horizontal.

In one or two slides which have developed in the cut, the surface on which the material was sliding, had a slope of one vertical to ten horizontal, and in the case of another slide on the west bank of the canal, north of the village of Culebra, the moving material, which consisted of stratified rock, was moving *en masse*, at the rate of three feet in 24 hours, on a lignite layer about six inches thick, which had a slope of about one vertical to seven horizontal and was underlaid by layers of sedimentary rock, which did not move. A rather remarkable thing about this last slide was that, like two or three other slides, it developed in the dry season and moved at a faster rate during the four months when there was no rain than it has done since the rains have come.

The writer is aware that there is a very general impression that slides are due solely to saturation by rainfall, or underground water, of the material which is in motion, and while this is to a great extent correct for the slides like the one described at Cucaracha, yet there have been three large slides, involving in all nearly 2,000,000 cubic yards of material, which developed during the dry season and were composed wholly of material so dry that when loaded on the trains, the cars were almost hidden during the windy season by

Culebra cut shall have been completed, not less than 22 per cent of all material excavated by the United States will have been removed on account of slides, and that they will have added twenty-one or twenty-two million cubic yards to the amount of material to be excavated.

On the other hand, while their existence has increased the difficulties of the work and has added very considerably to the amount of excavation, and consequently to the cost, yet they have so far presented no obstacles which cannot be overcome without delaying the predicted date for the opening of the canal; nor will the additional material excavated on account of slides require any further appropriation in excess of the estimate submitted by the chairman and chief engineer on September 1st, 1908.

In this estimate, the "Division Cost" of all dry excavation remaining to be done in the Central Division after September 1st, 1908, was given as 75 cents per cubic yard, whereas the total cost of all excavation in the Central Division from September 1st, 1908, to September 1, 1912, was but \$0.5134. The difference between the unit price submitted in the estimate and that at which the excavation was actually done between September 1st, 1908, and September 1st, 1912, amounts to a total of \$17,013,645, the amount of excavation in question, having been 71,908,898 cubic yards—about three fourths being rock.

It must not be understood, however, that this total of over seventeen million dollars will be a clear saving, as fully seventeen to eighteen million cubic yards in addition to the estimate of September 1st, 1908, will have been added by the slides before work in the Central Division has been completed; and besides, a considerable amount of work not then contemplated has since been done. Yet, in spite of these large additions, aggregating probably nineteen or twenty million cubic yards to the quantity of material as submitted

excavation taken out of the completed canal will reach the great total of 212,227,000 yards, the average citizen understands, of course, that this represents an enormous mass of material. But when he is told that if the excavated earth and rock were dumped along the line of Broadway, New York, it would prove sufficient to form no less than sixty-three great pyramids, reaching for a distance of nine miles from the Battery to Harlem, there is little danger of his failing to appreciate the magnitude of the task of excavation at Panama.

Everybody knows that much trouble has been given along the line of the canal by slides of great magnitude. When we read that the total amount of extra material additional to the original estimate of excavation, which must be painfully shoveled onto the cars and hauled away out of the Culebra cut amounts to over 20,000,000 cubic yards of earth and rock, we apprehend but do not comprehend what this means. But when we are told that this material, if built into one huge mass, would make a pyramid of solid material reaching along Broadway from Chambers Street to Fulton Street and extending from the City Hall in City Hall Park to West Broadway, and that the apex of this pyramid would tower one hundred feet above the top of the Woolworth Building, we comprehend what a vast amount of additional work has been imposed upon the engineers by the unstable and treacherous character of the volcanic material through which the canal is being dug.

Also we know that the concrete work which has been done in building the locks at Gatun, Miraflores and Pedro Miguel constitutes the biggest job of concreting ever undertaken. We understand, in a general way, that the four-and-a-half million cubic yards of concrete must represent a big bulk of materials. As a matter of fact, sufficient concrete has been put in the locks and dams of the canal to form a pyramid 960

(Concluded on page 405.)



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Pyrene Sales Co.,
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Yours very truly,
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The Greatest Engineering Work of All Time.

(Concluded from page 390.)

feet square at the base and 400 feet in height—a mass in other words, which, as our illustration shows, would entirely cover in and shut out of sight, the new Pennsylvania Terminal at New York and tower several hundred feet above the lofty roof of the main hall.

The Chinese Wall has always been considered to be a fairly big job of construction. It is fifteen hundred miles in length, and would reach from San Francisco to St. Louis. But the material taken out of the canal prism would build a wall 2,500 miles in length and of the same average thickness and height as the Chinese Wall, the structure reaching entirely across the United States. Again, the canal from shore to shore is only forty miles long, or fifty miles between the deep-water contours on each ocean. But the same amount of excavation would dig a canal 55 feet wide and 10 feet deep entirely across the United States.

Lastly, if all the excavated material were loaded onto flat cars it would form a dirt train sufficient to reach over four times around the globe; moreover the bore holes driven for blasting out this material, if placed end to end, would pass entirely through the earth.

The Sanitation of the Canal Zone

(Concluded from page 393.)

residence, in the tropics for colonies of northern white races, without any appreciable ill-effect on either their physique or mentality. But their remaining in good health is conditional upon properly conducted measures of sanitary prophylaxis. The question is not "Can a white colony live and labor in the tropics?" but rather, "Can a white colony afford to undertake the sanitary work necessary to make it possible for its members to live in health?" The last question can only be answered by a careful study of the conditions in a given locality. From the experience gained in Panama, in Cuba and in the Philippines, we believe that in most places the cost of sanitation can be made to fall well within the boundaries of economic feasibility, if directed by a competent sanitarian. Whether or not the Caucasian race can permanently inhabit the tropics, continue a healthy vigorous race and maintain a high degree of culture is a question I am not prepared to discuss. That under proper conditions Caucasians can live long enough in the tropics to accomplish a prodigious task of engineering, such as the Panama Canal, and do it without any great sacrifice either in lives or in health, has been demonstrated. To-day healthy and vigorous American men work with snap and vim under the hot sun of Panama, play baseball, tennis and other games. American women do housework, play tennis, ride horseback and dance enthusiastically, and chubby little American children, born and raised in Panama, play on the lawns and attend American schools. We have learned how to live in the tropics.

The Electrification of the Panama Canal

(Concluded from page 397.)

for a considerable period will suddenly be called upon to operate and must perform its function absolutely without fail. To insure this the best of machinery and the best methods of construction have been employed. Very special attention has been given to the conditions of humidity on the Isthmus and a suitable insulation for electrical machines to be used in such a place has been developed, after a study involving much expenditure of time and money. The prevention of corrosion of the metallic parts has also been given especial attention.

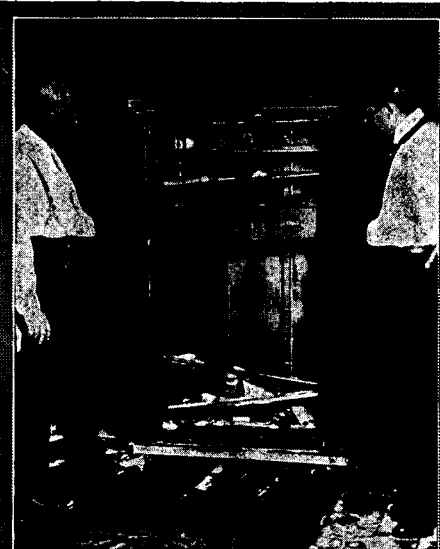
For operating the rising-stem gate valves, 116 50-horse-power motors will be employed. The function of these valves is to regulate the flow of water into and out of the locks from the upper level through the main culverts in the side and

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after witnessing actual fire tests of steel filing cabinets unreservedly declared that the best of them all is **THE SAFE-CABINET**

Ex-Fire-Chief Croker says:

"Wonderful! The test was very severe and it shows THE SAFE-CABINET to be proof against fire. The way it came through was wonderful."

Ex-Fire-Chief Archibald says:

"That settles the question. THE SAFE-CABINET is vastly superior to all other filing cabinets of which I have any knowledge."

Six of the best known double wall steel filing cabinets were successively placed in a specially constructed furnace. The most accurate scientific instruments for registering the external and internal temperature were used. The tests were conducted under the supervision of Prof. E. S. Merriam, of Marietta College, who personally checked all instruments and readings.

THE SAFE-CABINET

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was in the fire for 49 minutes, thirty of which averaged in excess of 1700 degrees Fahrenheit (estimated to be actual severe conflagration heat). The internal temperature at no time exceeded 290 degrees F. At the end of this ordeal a fire hose was turned on its white-hot doors and outer walls. THE SAFE-CABINET was then opened and its contents were found to be uninjured. Papers and currency, which had been placed in the cabinet before the test, were taken out in perfect condition.

The contents of the five cabinets

of other makes were in process of destruction at the end of periods ranging from 6 to 17 minutes, and in every case the destruction was completed before the completion of the test. Not one of the five was subjected to the fire for more than 28 minutes, some not more than 13 minutes.

We have issued a complete report of these tests, omitting only the names of the competing cabinets. The accuracy of this report is a matter of legal affidavit. Write for it. It is free.

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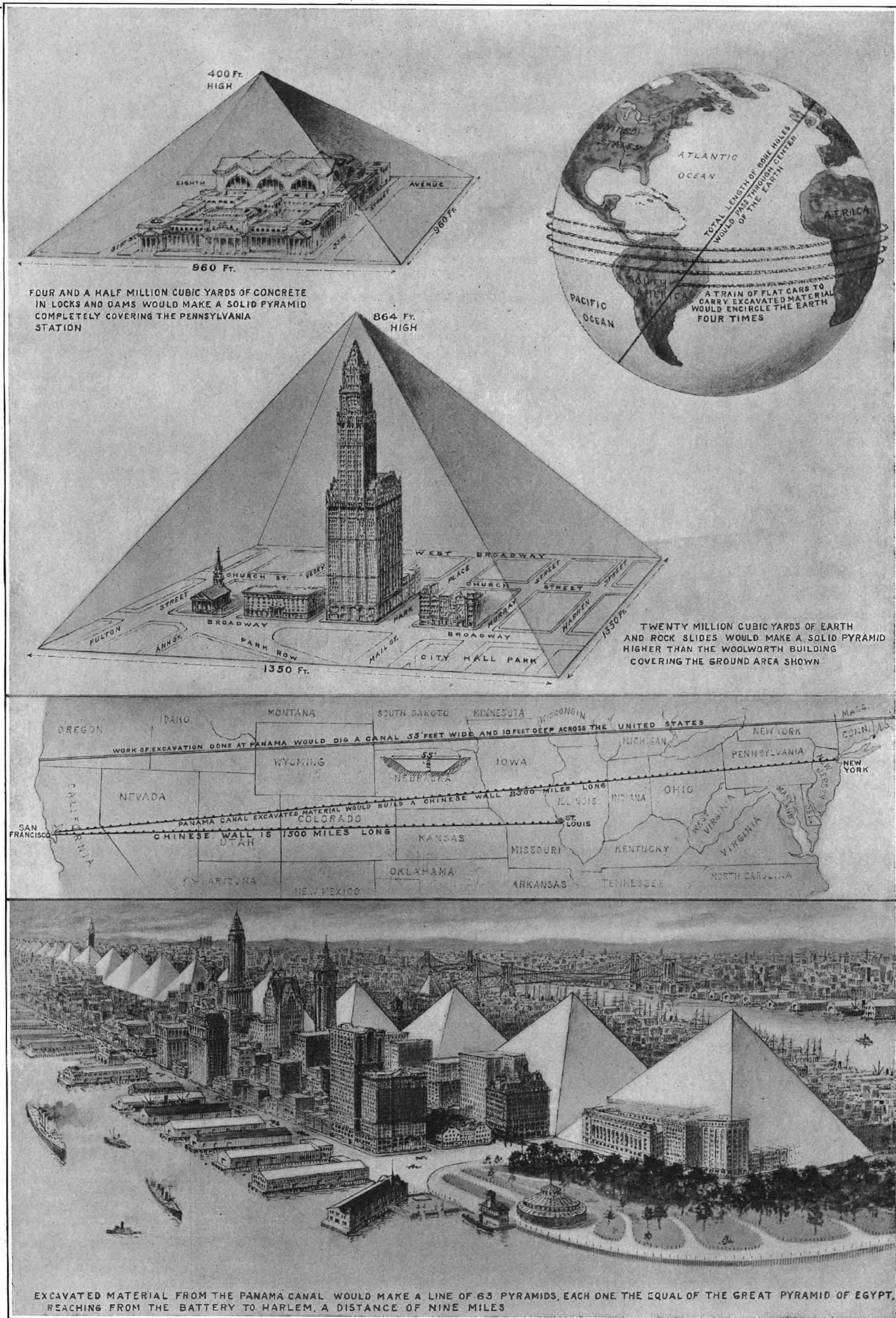
Standard of New York and Washington Fire Departments—Write for Pamphlet

Electrene Company

Whitehall Building, New York City



SIMPLY TURN THIS
NOZZLE
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AT THE FIRE



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Pictorial representation of the enormous quantities of material handled in constructing the Panama Canal.

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