

CHAPTER XII

THE CULEBRA CUT.

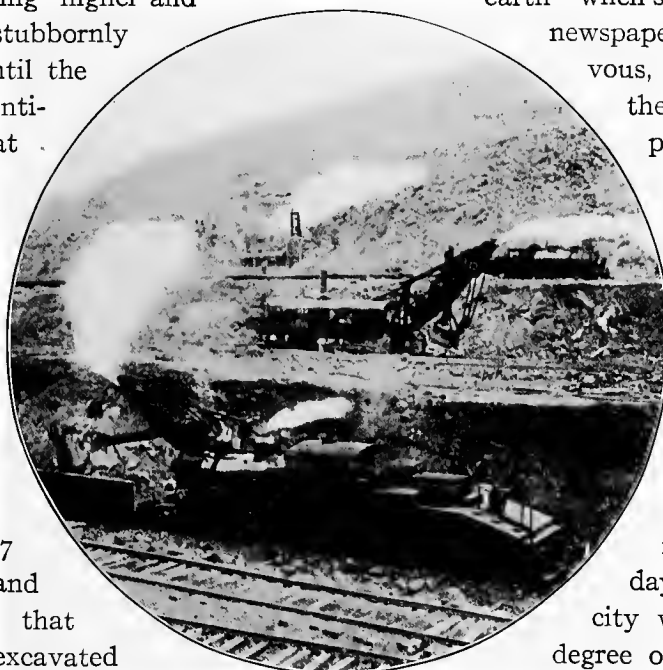


TECHNICALLY what is known as the Culebra Cut extends from Bas Obispo to the locks at Pedro Miguel, a distance of nine miles. To the general public understanding, however, the term applies only to the point of greatest excavation between Gold Hill and Contractor's Hill. But at Bas Obispo the walls of the Canal

for the first time rise above the water level of Gatun Lake. At that point the cutting begins, the walls rising higher and higher, the Canal pressing stubbornly onward at a dead level, until the supreme height of the continental divide is attained at Gold Hill. Thenceforward on the line toward Panama City the hills grow lower until at the entrance to the locks at Pedro Miguel the banks sink practically to the water level. Out of this nine mile stretch there had been taken up to January 1, 1913, just 88,531,237 cubic yards of material and it was then estimated that there then remained to be excavated

5,351,419 cubic yards more. But the later estimate was destined to be largely increased for, after the date at which it was made, the number and extent of "slides" in the deepest part of the cut increased to staggering proportions. Col. D. D. Gaillard, Member of the Commission and Division Engineer in charge of the Culebra Cut, estimated in 1912 that in all 115,000,000 cubic yards would have to be removed.

To the general public the slides seemed to menace



the very existence and practicability of the Canal, though the engineers knew that they began even with the superficial excavating done by the French, and had therefore made allowance for them in their estimates. Not sufficient allowance however was made, and as month after month brought tidings of new slides, with terrifying details of such incidents as whole forests moving, vast cracks opening in the earth, large buildings in imminent danger of being swept into the Cut, the bottom of the Canal mysteriously rising ten to fifteen feet in the air, while smoke oozed from the pores of the adjacent earth—when such direful reports filled the

newspapers the public became nervous, almost abandoning hope of the success of the great enterprise.

This attitude of apprehension on the part of the public is scarcely surprising. If the Capitol Park at Washington, with the National Capitol cresting it, should suddenly begin to move down into Pennsylvania Avenue at the rate of about three feet a day the authorities of the city would naturally feel some degree of annoyance. And if the

smooth and level asphalt of that historic thoroughfare should, over night, rise up into the air 18 feet in spots those responsible for traffic might not unreasonably be somewhat worried.

Such a phenomenon would not be so startling in mere magnitude as the slides which added so greatly to the work of the engineers on the Canal, and made tourists, wise with the ripe fruits of five days' observation, wag their heads knowingly when Col.



Courtesy of Scientific American

THE ORIGINAL CULEBRA SLIDE

A Y. M. C. A. club had to be moved to escape this slide which in 1913 was still moving

Goethals calmly repeated his assertion that the water would be turned in by August. The Colonel, however, had not withdrawn or even modified this prophecy so late as June 10, 1913. Despite the almost daily news of increased activity of the slides he clung with tenacity to his purpose of putting a ship through in October.

If these slides were an entirely new and unexpected development for which no allowance of either time or money had been made in the estimates of the Canal builders they would of course justify the apprehension they have awakened in the non-professional mind. But the slides were in fact anticipated. The first slide recorded during our work on the Isthmus was in 1905; the others have only been bigger, and have been bigger only because the Canal being dug deeper has weakened the bases of even bigger hills along the banks. All the same, the proportions of the slides are terrifying and the chief geologist declared that they would not cease until the angle of the Canal bank became so gentle that gravity would not pull the crest down.

The slides are of two sorts. The simpler is a mere swift rush of all the loose surface dirt, sand, gravel and stone down the surface of the bank. These gravity slides, mere dirt avalanches, though trouble-

some, present no new problems. To stop them it is necessary only to carry the crest of the bank further back so that the angle will be less steep. But the great, troublesome slides are those caused by the pressure of the hill-top on its undermined and weakened base. These originate at the top of the hill, making their presence known by gaping fissures opening in the earth and extending in lines roughly parallel to the Canal. Once started the whole mass, acres in extent, moves slowly toward the cavity of the Canal, three feet a day being its swiftest recorded progress. At Culebra the slides compelled the moving of a large part of the town away from the edge of the Cut, lest it be swept into the gorge. The Culebra Y. M. C. A. clubhouse, the largest on the Zone had to be torn down to escape this peril.

As the slide moves slowly downward, its colossal weight applied at points where nature had made no provision for it, forces the earth upward at the point where it can offer the least resistance, namely the bed of the Canal. Sometimes this upheaval, so mysterious to the non-technical mind, attains a height of eighteen feet. Again, the friction of this huge mass of stone and gravel creates heat, which turns into steam the rills of water that everywhere

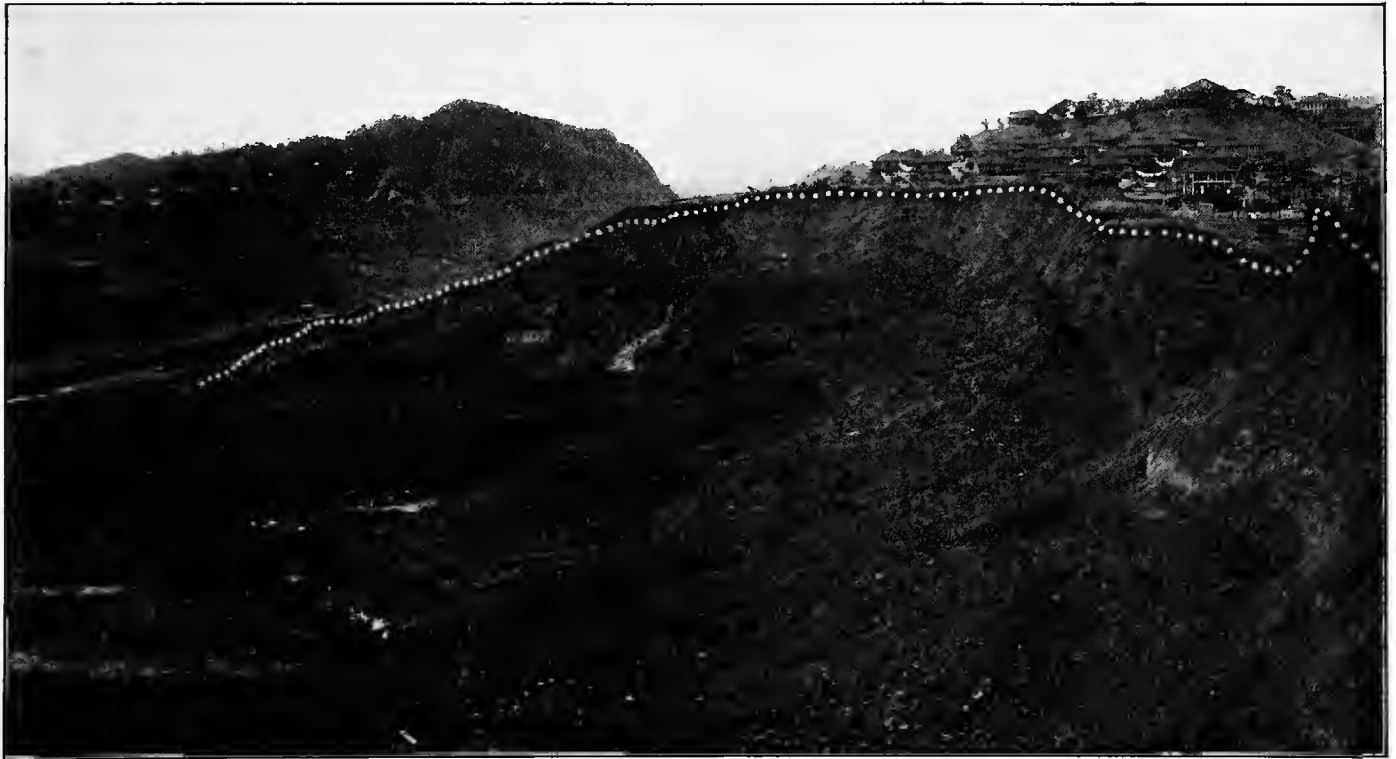
percolates through the soil. The upheaval of the Canal bed, and the occasional outpourings of steam have led at times to exaggerated and wholly unfounded reports in the newspapers of volcanic action being one of the new problems with which the Canal builders had to grapple.

The story told about the extent of the slides is sufficiently alarming, but the calmness with which Col. Goethals and his lieutenants meet the situation is reassuring. According to the official report there were twenty-six slides and breaks in Culebra Cut to January 1, 1913 with a total area of 225 acres. Since that date many others have occurred. It is estimated that because of slides between 21,000,000 and 22,000,000 cubic yards of material in excess of the original estimate will have been taken out of the Cut before completion. This is just about one-fifth of the total amount of excavation, dry and wet, estimated originally for the whole Canal. But the attitude of the engineers toward this addition to their labors was merely one of calm acceptance of the inevitable and a dogged determination to get the stuff out of the way. The slides were an obstacle; so was the whole isthmus for that matter.

But all that was necessary was to keep the shovels working and the slides would be removed and the isthmus pierced.

To my mind one of the finest evidences of the spirit animating the Canal force was the fashion in which this problem of the slides has been approached. It was at first disappointing, almost demoralizing, to find over night the work of weeks undone and the day when "finis" could be written to the volume put far over into the future. But the only effect was a tighter grip on the pick and the shovel, a new determination to force through the Canal. Culebra was approached as Grant approached Vicksburg. To reduce it and to open the Canal to traffic, as Grant opened the Mississippi to the steamboats of the nation, took more time than was at first expected, but it had to be done. The dirt could not always slide in faster than it could be carted out, for in time there would be no dirt left to slide. And so, undismayed and intent upon success, the whole force from Col. Goethals to the youngest engineer moved on Culebra and the doom of that stubborn block to progress was sealed.

To the unscientific mind the slides are terrifying



SLIDE ON WEST BANK OF THE CANAL NEAR CULEBRA

Picture shows about 1,000,000 cubic yards of material moving toward the cut at about three yards a day



ATTACKING THE CUCARACHA SLIDE

This slide has filled the Cut from side to side. A partial Cut has been dug through its center and the shovels are seen working on either side. The tracks are moved nightly as the material is removed.

in their magnitude and in the evidence they give of irresistible force. Man can no more check their advance than he can that of a glacier which in a way they resemble. When I was on the Isthmus the great Cucaracha slide was in progress, and had been for that matter since 1907. It had a total area of 47 acres and extended up the east bank of the Canal for about 1900 feet from the axis of the Canal. When it began its progress was disconcertingly rapid. Its base, foot, or "toe"—these anatomical terms in engineering are sometimes perplexing—moved across the canal bed at the rate of 14 feet a day. All that stood in its path was buried, torn to pieces or carried along with the resistless glacier of mud. Not content with filling the Canal from one side to the other, the dirt rose on the further side to a height of about 30 feet. Not only was the work of months obliterated, but work was laid out for years to come. Indeed in 1913 they were still digging at the Cucaracha slide and the end was not in sight. This slide was wholly a gravity slide, caused by a mass of earth slipping on the inclined surface of some smooth and

slippery material like clay on which it rests. The nature of the phenomenon is clearly shown by the diagram printed on the next page in which the slide marked C is of the type just described.

On the west bank of the Canal occurred a slide of the second type caused by the crushing and squeezing out of underlying layers of soft material by the prodigious pressure of the high banks left untouched by the steam shovels. This slide is usually accompanied by the uprising of the bed of the Canal sometimes to a height of thirty feet. Col. Gaillard tells of standing on the bed of the Canal, observing the working of a steam shovel, when it gradually dawned upon him that he was no longer on the level of the shovel. At first he thought that the shovel must have been placed upon a bit of boggy land and was slowly sinking, but on investigation he discovered that the point on which he was standing had been slowly rising until within five minutes he had been lifted six feet without jar and with no sensation of motion. A perfectly simple illustration of the way in which this elevation of the bed of the Canal

is caused may be obtained by pressing the hand upon a pan of dough. The dough will of course rise at the side of the hand. On the "big job" the towering hills furnished the pressure, the bed of the Canal rose like the dough. In the diagram already referred to, the slide to the right marked "B" is of the type here described. To cope with it, the work of the shovels and dirt trains in the Canal carrying the débris away is supplemented by others above removing the crest of the slide and thus lightening the pressure. In the diagram shovels are shown thus working on two levels, but I have seen four terraces of the same slide bearing steam shovels and rumbling dirt trains hurrying the débris away to where it will no longer be a menace.

The Culebra slide possessed a certain remorselessness which was not manifested by any of the others

in quite so picturesque a way. For this slide, with apparently human malice, attacked not only the work done on the Canal proper, but like a well directed army moved on the headquarters of its foe. Its first manifestation appeared in the form of a wide crack in the earth at the crest of the hill on which sits the town of Culebra, and directly in front of the building used by Col. Gailard as division headquarters for the engineers. Retreat was the only course possible in the face of such an enemy and the

building was sacrificed. The Culebra Y. M. C. A. clubhouse too was a point of attack for the remorseless foe. It stood on the very crest of the hill, a beautiful building on a most beautiful site. The serpent of Culebra Cut—the word "culebra" means snake—saw this pleasant place of rest and marked it for his own. Nothing remained but to rally a force of men and tear the

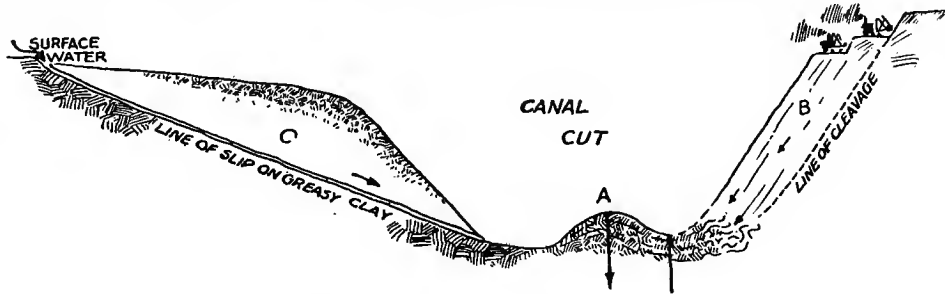


DIAGRAM OF CULEBRA CUT SLIDES

C. is a slide moving over a slippery surface; the mass B breaks on a line of cleavage and crushes the underlying material, forcing it up at A. The steam shovels are working to reduce pressure on B



Courtesy of Scientific American

A ROCK SLIDE NEAR EMPIRE

About 400,000 cubic yards of rock broke away, half filling the cut and opening it to the water of the Obispo Diversion Canal



THE AUTHOR AT CULEBRA CUT

building down for reerection at some other point. It was probably the largest and most attractive clubhouse on the Zone, but where it once stood there was a nearly sheer drop of about sixty feet, when first I visited the scene of the slide. Before the spot, too, on which the engineering headquarters had stood, there was a patch of lawn that had slid some eighty feet down into the Cut. With it traveled along a young eucalyptus tree waving its leaves defiantly in the face of the enemy that was bearing it to irrevocable disaster. Whether the Culebra slide had attained its fullest proportions in 1913 could not be told with certainty though the belief was current that it had. While the crest of the hill had not been fully reached, the top of the slide began at the edge of a sort of jog or terrace that extended away from the Cut some distance on a level before the ground began to slope upward again. Should it extend further a very considerable and beautiful part of the town would be destroyed, but as it is to be abandoned in any event on the completion of the Canal, this phase of the matter does not give the Commission much concern.

A third slide, of lesser proportions which seriously complicated the work of the engineers, occurred near Empire

in August, 1912. Here about 400,000 cubic yards of rock slipped into the Cut, wrecking cars, destroying tracks and machinery and flooding the Canal with water from the Obispo diversion. It is not generally known that parallel to the Canal at various points are dug smaller canals, or big ditches, for the purpose of catching and carrying off the heavy annual rainfall on the canal watershed. These diversion ditches cost much in time and labor. One was constructed by the French. Another, $5\frac{1}{4}$ miles long, known as the Obispo diversion, cost \$1,250,000 and was absolutely essential to the construction of the Canal. The rock slide, above referred to, broke down the barrier between the Canal cut and the diversion ditch and filled the former with an untimely flood which it took time to stay and pump out.

From all parts of the United States citizens interested in the progress of the Canal—and only those at the work can tell how widespread and patriotic that interest is—have sent suggestions for checking these slides. Practically all have been impracticable—a few only indeed have been thought worthy of being put to the test. One that for a time seemed worth trying was the suggestion that the wall of the cut be plastered with concrete, binding its surface together in a solid mass. But upon that being done it was demonstrated that the slides were not superficial but basic, and concrete face and all went down to one general destruction when the movement began. One curious

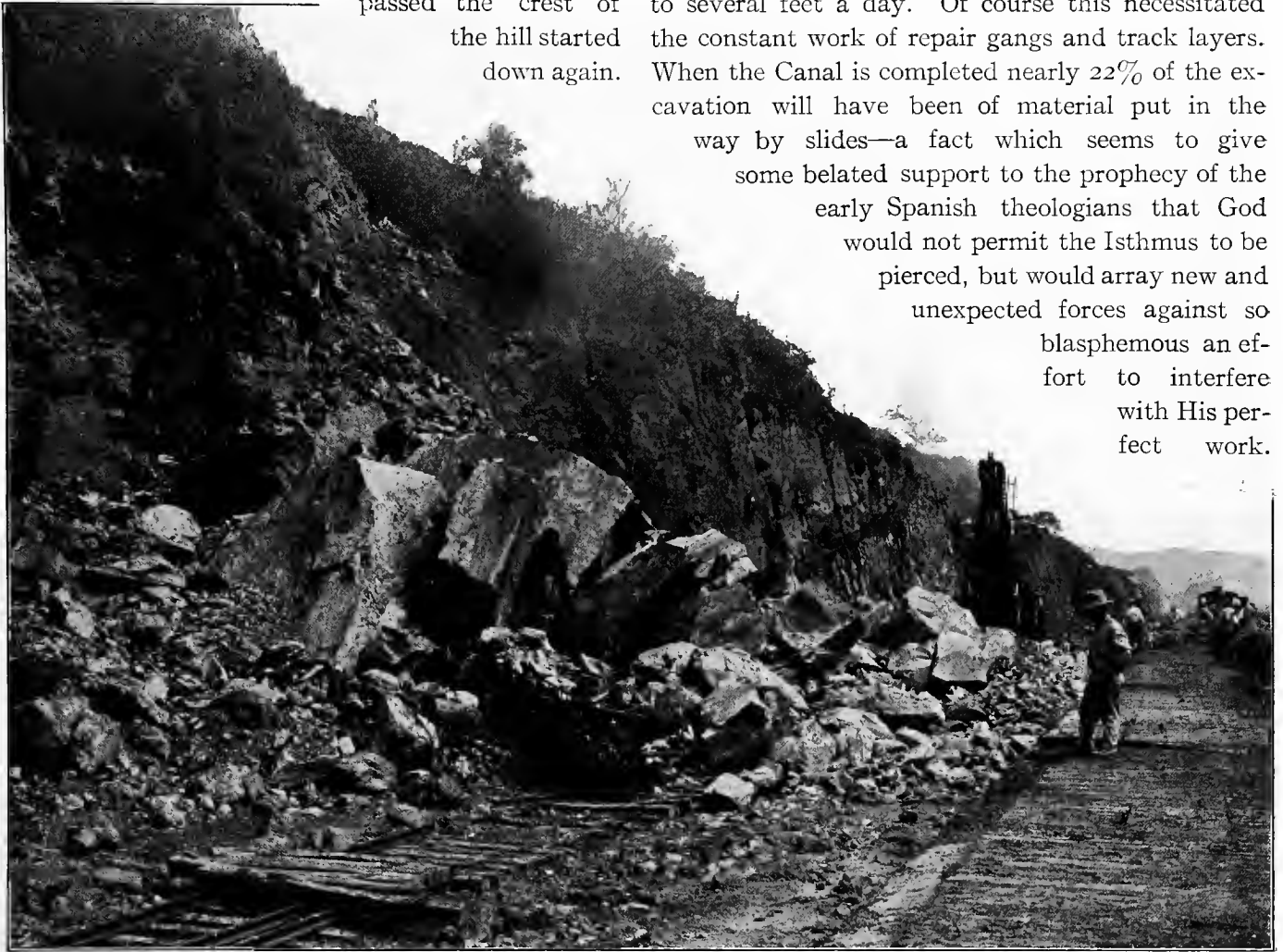


CUTTING AT BASE OF CONTRACTORS HILL

This shows the point at which the Cut is deepest. The actual level of canal bed was not reached at the time this photograph was taken

fact about the slides is that they do not invariably slide *down* throughout their entire course. Occasionally they take a turn upward. One tree at Cucaracha was pointed out to me which after moving majestically down for a space was carried upward over a slope for 100 feet, and then having passed the crest of the hill started down again.

upon time and labor however has been heavy enough. Within the $8\frac{1}{5}$ miles of the Culebra Cut fully 200 miles of track have been covered up, destroyed or necessarily rebuilt because of slides, and at one point tracks had to be maintained for nearly two years on ground moving from three or four inches to several feet a day. Of course this necessitated the constant work of repair gangs and track layers. When the Canal is completed nearly 22% of the excavation will have been of material put in the way by slides—a fact which seems to give some belated support to the prophecy of the early Spanish theologians that God would not permit the Isthmus to be pierced, but would array new and unexpected forces against so blasphemous an effort to interfere with His perfect work.



A ROCK SLIDE AT LAS CASCADES

A steam shovel was wholly demolished but its operators escaped. The slides have seldom cost lives

The slides are by no means wholly in the wet season despite the popular impression to that effect, though it was in the height of that season that the one at Cucaracha began. Yet I have seen a slide moving slowly in January when the shovels digging fiercely at its base were enshrouded in clouds of dust. Curiously enough though tracks have been torn up, machinery engulfed and wrung into indistinguishable tangles of steel, no man was caught in any of these avalanches prior to May, 1913, when three were thus lost. The tax they have put

One feature of the slides which would surely have awed the pious prophets of the Spanish day, and which did indeed considerably perplex our more prosaic engineers, was the little wisps of smoke that arose from the slowly moving soil. That this was volcanic few believed, except some newspaper correspondents in eager search for sensations. The true explanation that heat generated by friction working upon the water in the earth caused the steam was all very well and complete as an explanation of that particular phenomenon. But it left a

certain worried feeling in the minds of the men who spent their days in putting hundreds of plugs of dynamite into holes drilled in the rock which the scientists declared superheated. Dropping a dynamite cartridge into a red-hot rock is apt to create a menace to the continued life and health of the dropper which even the excellent sanitary brigade of Col. Gorgas could scarcely control successfully. For a time there was a halt in the blasting operations and indeed two blasts were fired prematurely by this natural heat, but fortunately without loss of life. Finally the scheme was devised of thrusting an iron pipe into the drill hole and leaving it there a few minutes. If it was cool to the touch on withdrawal all was well; if hot a stream of water was kept playing in the hole while the charge was inserted and tamped down.

Dynamite has been man's most useful slave in this great work, but like all slaves it now and then rises in fierce and murderous revolt. "Though during the past three and one-quarter years, in work under the writer's charge", writes Col. Gaillard, "over 20,000,000 pounds of



Photo by Underwood & Underwood

SLICING OFF THE CHIEF ENGINEER'S OFFICE

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

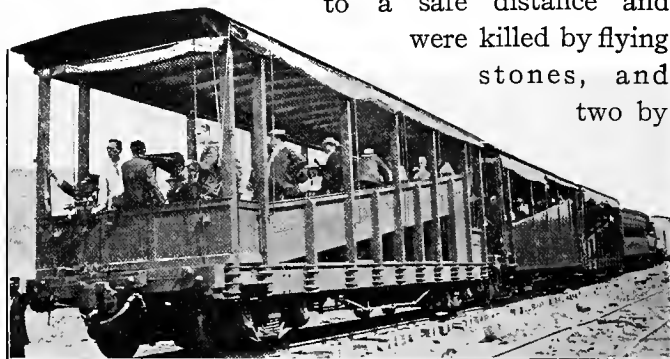


Photo by Underwood & Underwood

HOW TOURISTS SEE THE CUT

The picture shows Vincent Astor's party in the observation car

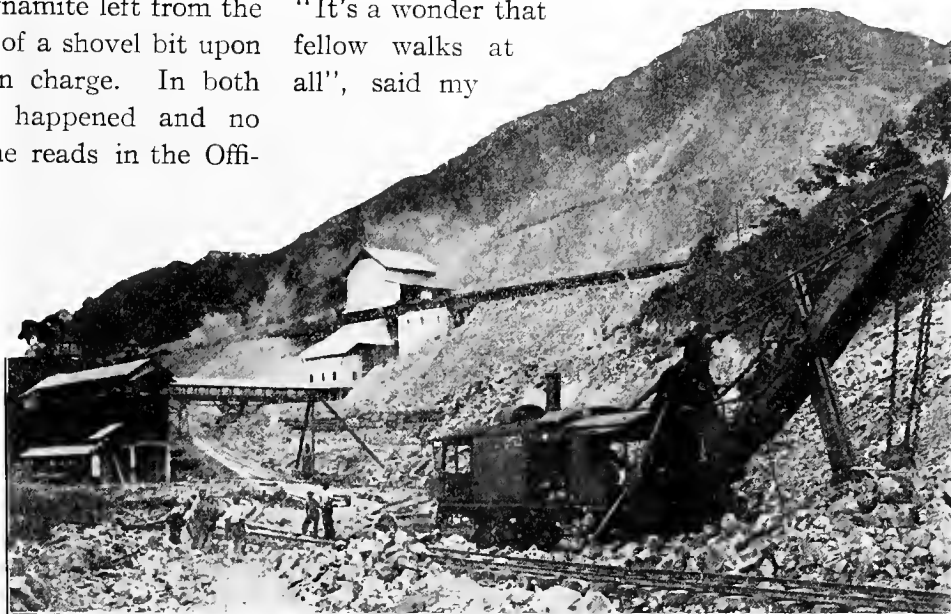
miscounting the number of shots which had gone off in a 'dobe' group, and approaching the group before the last shot had exploded".

Something like 12,000,000 pounds of dynamite a year was imported from "the states" to keep the job going, over 6,000,000 pounds a year being used in Culebra Cut alone, and many an unsuspecting passenger danced over the tossing Atlantic waves with a cargo beneath him explosive enough to blow him to the moon. On the Zone the stuff is handled with all the care that long familiarity has shown to be necessary, but to the uninitiated it looks careless enough. It is however a fact that the accidents are continually lessening in number and in fatalities caused. The greatest accident of all occurred December 12, 1908, when we had been only four years on the job. It was at Bas Obispo, and in order to throw over the face of a hill of rock that rose from the west bank of the Canal at that point nearly 44,000 pounds of dynamite had been neatly tamped away in the holes drilled for that purpose. Actually the last hole of this prodigious battery was being tamped when it exploded and set off all the others. A colossal concussion shook all the face of the earth. The side of the hill vanished in a cloud of smoke and dust from which flying rocks and trees rose into the air. When the roar of the explosion died away cries of anguish rose on the trembling air. About the scene of the explosion an army of men had been working, and of these 26 had been killed outright and a host more wounded. No such disaster has ever occurred again though there have been several small ones, and many narrow escapes from large ones.

Once a steam shovel taking its accustomed bite of four or five cubic yards of dirt, engulfed at the same time about a bushel of dynamite left from the French days. Again the teeth of a shovel bit upon the fulminate cap of a forgotten charge. In both these cases the miraculous happened and no explosion occurred. When one reads in the Official Handbook issued by the Commission that a pound of dynamite has been used to about every two cubic yards of material blasted, and compares it with the total excavation of about 200,000,000 cubic yards one thinks that even the undoubted sins of the Isthmus during its riotous days are expiated by such a vigorous blowing up.

One day at Matachin an engineer with whom I was talking called a Span-

iard and sent him off on an errand. I noticed the man walked queerly and commented on it. "It's a wonder that fellow walks at all", said my



HANDLING ROCK IN ANCON QUARRY

friend with a laugh. "He was sitting on a ledge once when a blast below went off prematurely and Miguel, with three or four other men, and a few tons of rock, dirt and other debris went up into the air. He was literally blown at least 80 feet high. The other men were killed, but we found signs of life in him and shipped him to the hospital where he stayed nearly eight months. I'd hesitate to tell you how many bones were broken, but I think the spine was the only one not fractured that was dislocated. His job is safe for the rest of his life. He loves to tell about it. Wait until he gets back and I'll ask him".

Only Miguel retained, sideways, the fragments of what they all said. "I don't remember how many feet he was blown up," said Miguel. "I lost one of my legs and a piece of my pipe, which was stuck in the ground when it went up, up, up. I stopped when I stop for a time. My arm was broken. By the way, I started to say 'Bang, I hit the ground' but I never got to the hospital."

Miguel never fails to let me know the details of his accident, and I have often found him on the subject with other men. The correct part of the story is that



MIGUEL AT ANCON

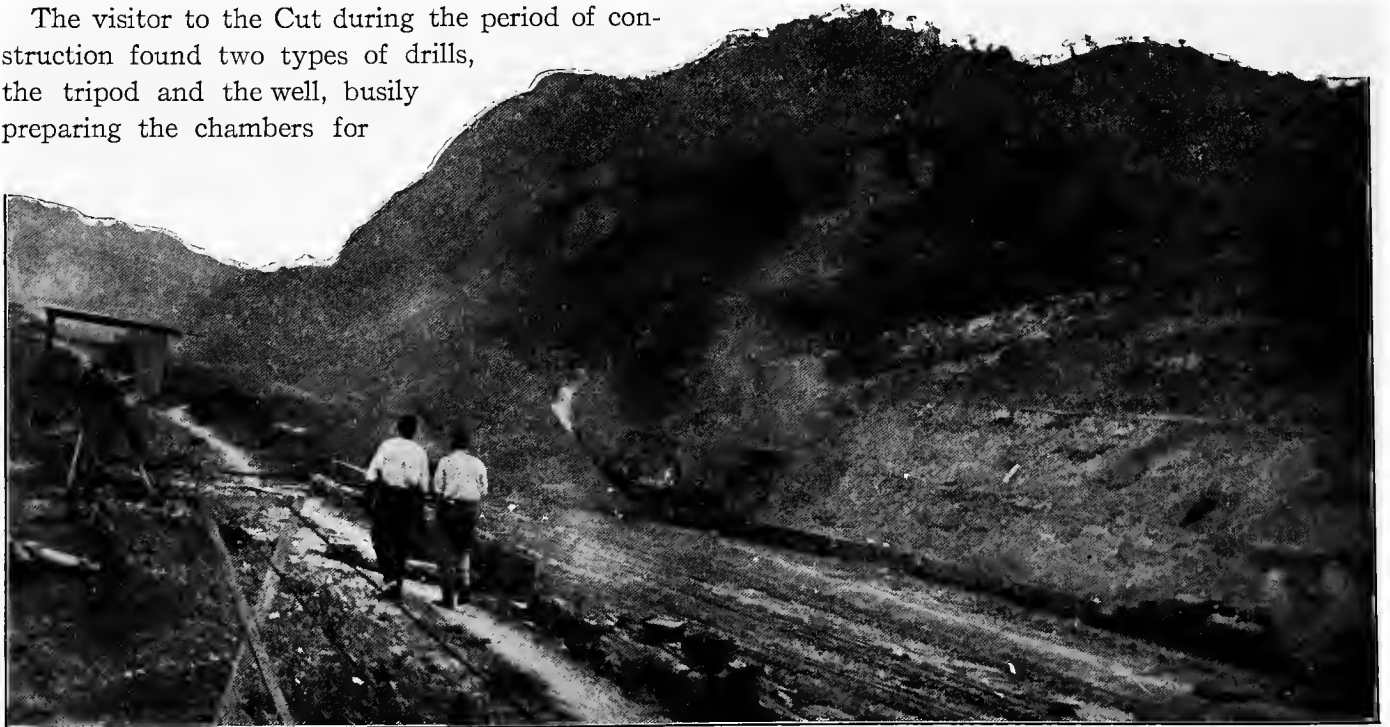
going up. His chief sorrow is that no moving picture man took the incident”.

Incidents of heroic self-sacrifice are not unknown among the dynamite handlers. Here is the story of Angel Alvarez, an humble worker on the Big Job. He was getting ready a surface blast of dynamite and all around him men were working in calm assurance that he would notify them before the explosion. Happening to glance up he saw a great boulder just starting to slip down the cut into the pit where he stood with two open boxes of dynamite. He knew that disaster impended. He could have jumped from the pit and run, saving himself but sacrificing his comrades. Instead he shouted a frantic warning, and seizing the two boxes of dynamite thrust them aside out of the way of the falling boulder. There was no hope for him. The rock would have crushed him in any event. But one stick of dynamite fell from one of the boxes and was exploded—though the colossal explosion that might have occurred was averted. They thought that Alvarez was broken to bits when they gathered him up, but the surgeons patched him up, and made a kind of a man out of him. Not very shapely or vigorous is Angel Alvarez now but in a sense he carries the lives of twenty men he saved in that moment of swift decision.

The visitor to the Cut during the period of construction found two types of drills, the tripod and the well, busily preparing the chambers for

the reception of the dynamite. Of the former there were 221 in use, of the latter 156. With this battery over 90 miles of holes have been excavated in a month, each hole being about 27 feet deep. The drills are operated by compressed air supplied from a main running the length of the Cut and are in batteries of three to eight manned by Jamaica negroes who look as if the business of standing by and watching the drill automatically eat its way into the rock heartily agreed with their conception of the right sort of work.

He who did not see the Culebra Cut during the mighty work of excavation missed one of the great spectacles of the ages—a sight that at no other time, or place was, or will be, given to man to see. How it was best seen many visits left me unable to determine. From its crest on a working day you looked down upon a mighty rift in the earth's crust, at the base of which pigmy engines and ant-like forms were rushing to and fro without seeming plan or reason. Through the murky atmosphere strange sounds rose up and smote the ear of the onlooker with resounding clamor. He heard the strident clink, clink of the drills eating their way into the rock; the shrill whistles of the locomotives giving warning of some small blast, for the great charges

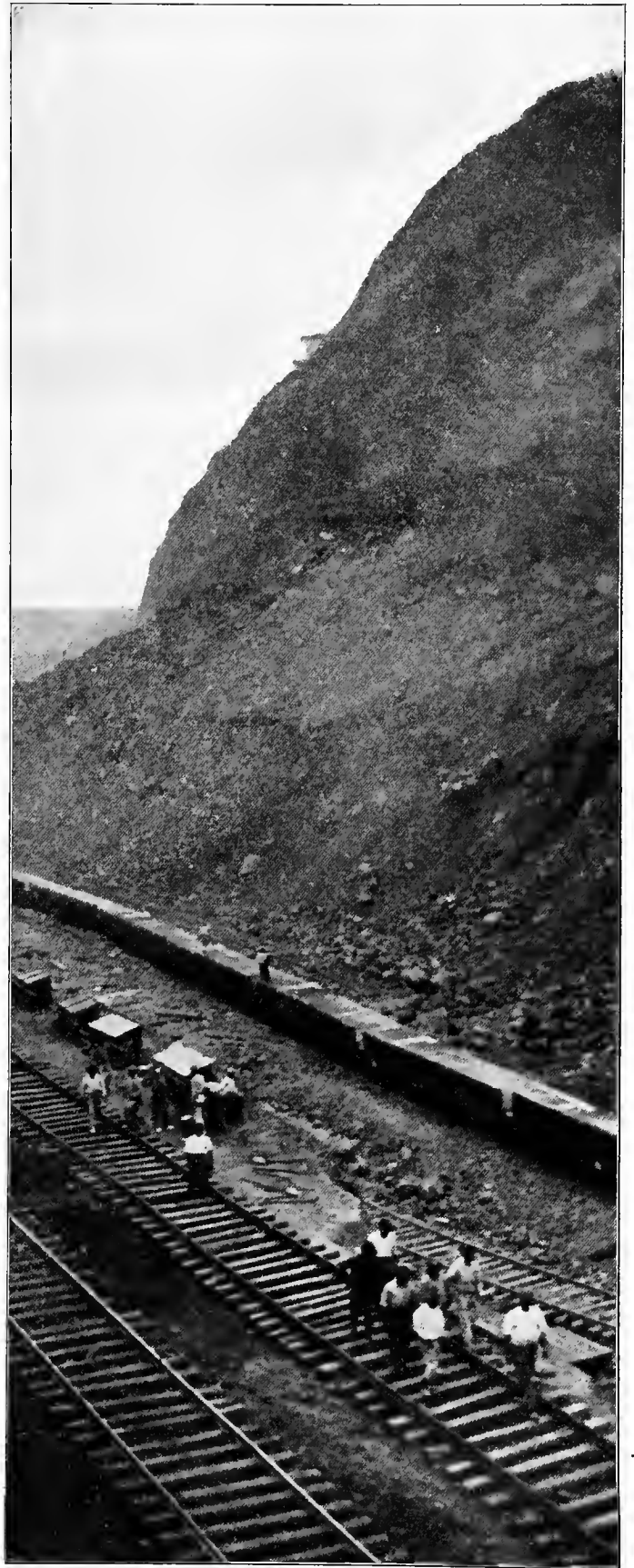


IN THE CUCARACHA SLIDE

were set off out of working hours when the Cut was empty; the constant and uninterrupted rumble that told of the dirt trains ever plying over the crowded tracks; the heavy crash that accompanied the dumping of a six-ton boulder onto a flat car; the clanking of chains and the creaking of machinery as the arms of the steam shovels swung around looking for another load; the cries of men, and the booming of blasts. Collectively the sounds were harsh, deafening, brutal such as we might fancy would arise from hell were the lid of that place of fire and torment to be lifted.

But individually each sound betokened useful work and service in the cause of man and progress as truly as could the musical tinkle of cow bells, the murmur of water over a village millwheel, or the rude melody of the sailors' songs as they trim the yards for the voyage to the distant isles of spice. The hum of industry that the poets have loved to tell about loses nothing of its significance when from a hum it rises to a roar. Only not all the poets can catch the meaning of its new note.

So much for the sounds of the Culebra Cut on a work day. The sights are yet more wonderful. One who has looked upon the Grand Canyon of the Colorado will find in this man-made gash in the hills something of the riot of color that characterizes that greatest of natural wonders, but he who has had no such preparation will stand amazed before the barbaric wealth of hues which blaze forth from these precipitous walls. Reds predominate—red of as deep a crimson as though Mother Earth's bosom thus cruelly slashed and scarred was giving up its very life's blood; red shading into orange, tropical, hot, riotous, pulsing like the life of the old Isthmus that is being carved away to make place for the new; red, pale, pinkish, shading down almost to rose color as delicate as the hue on a maiden's cheek, typifying perhaps the first blush of the bride in the wedding of the Atlantic to the Pacific. Yellow too from the brightest orange to the palest ochre, and blue from the shade of indigo which Columbus hoped to bring across this very Isthmus from the bazaars of Cathay; purple as royal as Ferdinand and Isabella ever wore, or the paler shades of the tropic sky are there. As you look upon the dazzling array strung out before you for miles you may reflect that imbedded in those parti-



BROW OF GOLD HILL, CULEBRA CUT

colored rocks and clays are semi-precious stones of varied shades and sorts—beryls, moss agates, blood-stones, moonstones which the workmen pick up and sell to rude lapidaries who cut and sell them to tourists. But in all this colossal tearing up of the earth's surface there has been found none of the gold for which the first white men lusted, nor any precious stone or useful mineral whatsoever.

Again I looked on the Cut from above one morning before the breeze that blows across the Isthmus from nine o'clock in the morning until sundown, had driven out of it the mists of early dawn. From unseen depths filled with billowy vapor rose the clatter of strenuous toil by men and machines, softened somewhat by the fleecy material through which they penetrated. Of the workers no sign appeared until the growing heat of the sun and the freshening breeze began to sweep the Cut clear in its higher reaches, and there on the topmost terrace of Gold Hill, half a mile across the abyss from where I stood, was revealed a monster steam shovel digging away at the crest of the hill to lighten the weight that was crowding acres upon acres of broken soil into the canal below. It seemed like a mechanical device on some gigantic stage, as with noiseless



"EVERY BITE RECORDED AT HEADQUARTERS"

ferocity it burrowed into the hillside, then shaking and trembling with the effort swung back its long arm and disgorged its huge mouthful on the waiting flat cars. The curtain of mist was slowly disappearing. From my lofty eyrie on an outjutting point of Contractor's Hill it seemed as if the stage was being displayed, not by the lifting of a curtain, but rather by the withdrawal of a shield downward so that the higher scenery became first visible. One by one the terraces cut into the lofty hillsides were exposed to view, each with its line of tugging steam shovels and its rows of motionless empty cars, or rolling filled ones rumbling away to the distant dump. Now and again a sudden eruption of stones and dirt above the shield of fog followed in a few seconds by a dull boom told of some blast. So dense was the mist that one marvelled how in that narrow lane below, filled with railroad tracks, and with busy trains rushing back and forth men could work save at imminent danger of disaster. Death lurked there

at all times and the gray covering of fog was more than once in the truest sense a pall for some poor mutilated human frame.

Perhaps the most impressive view of the Cut in the days of its activity was that from above. It was the one which gave the broadest general sense of the prodigious proportions of the work. But a more terrifying one, as well as a more

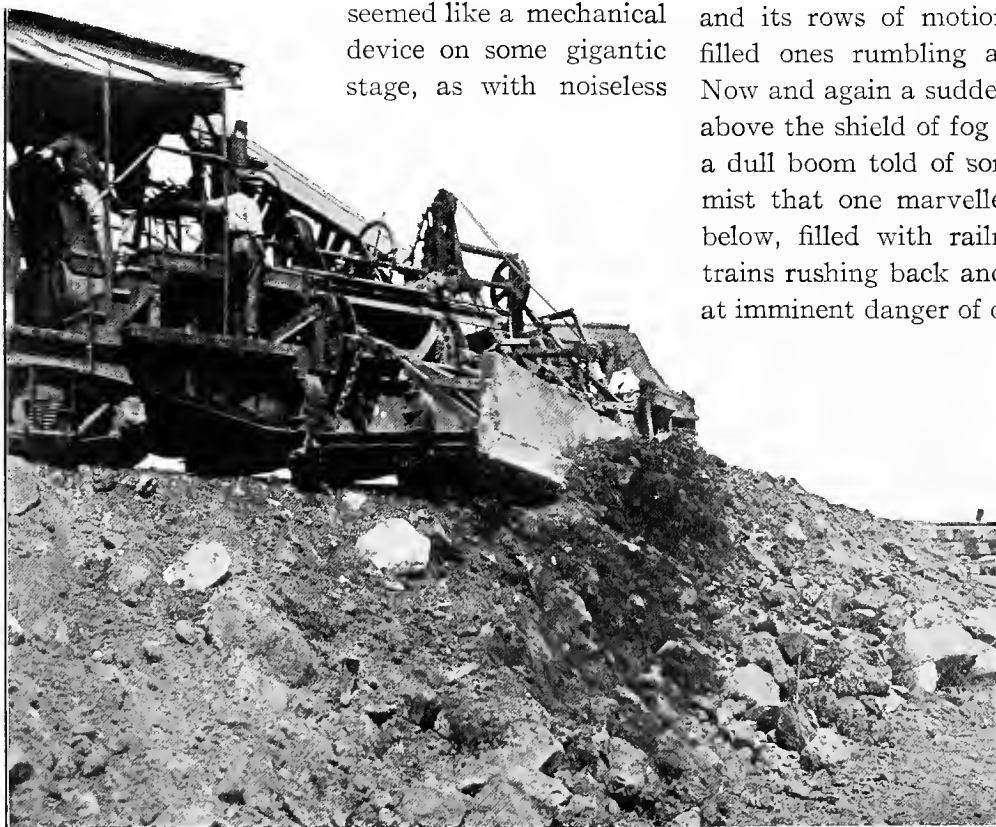


Photo by Underwood & Underwood

A DIRT-SPREADER AT WORK

precise comprehension of the infinity of detail coupled with the magnitude of scope of the work was to be obtained by plodding on foot through the five miles where the battle of Culebra was being most fiercely fought. The powers that be—or that were—did not encourage this method of observation. They preferred to send visitors through this Death's Lane, this confusing network of busy tracks, in an observation car built for the purpose, or in one of the trim little motor cars built to run on the railroad tracks for the use of officials. From the fact that one of the latter bore the somewhat significant nickname "The Yellow Peril" and from stories of accidents which had occurred to occupants of these little scouts among the mighty engines of war, I am inclined to think that the journey on foot, if more wearisome, was not more perilous.

Put on then a suit of khaki with stout shoes and take the train for Culebra. That will be as good a spot as any to descend into the Cut, and we will find there some airy rows of perpendicular ladders connecting the various levels up and down which an agile monkey, or Col. Gaillard or any of his assistants, can run with ease, but which we descend with infinite caution and some measure of nervous apprehension. Probably the first sound that will greet your ears above the general clatter, when you have attained the floor of the Canal will be a stentorian



THE TRACK SHIFTER IN ACTION

cry of "Look out, there! Look out"! You will hear that warning hail many a time and oft in the forenoon's walk we are about to take. I don't know of any spot where Edward Everett Hale's motto, "Look Out and Not In; Look Up and Not Down; Look Forward and Not Back" needs editing more than at Culebra. The wise man looked all those ways and then some. For trains are bearing down upon you from all directions and so close are the tracks and so numerous the switches that it is impossible to tell the zone of safety except by observing the trains themselves. If your gaze is too intently fixed on one point a warning cry may call your attention to the arm of a steam shovel above

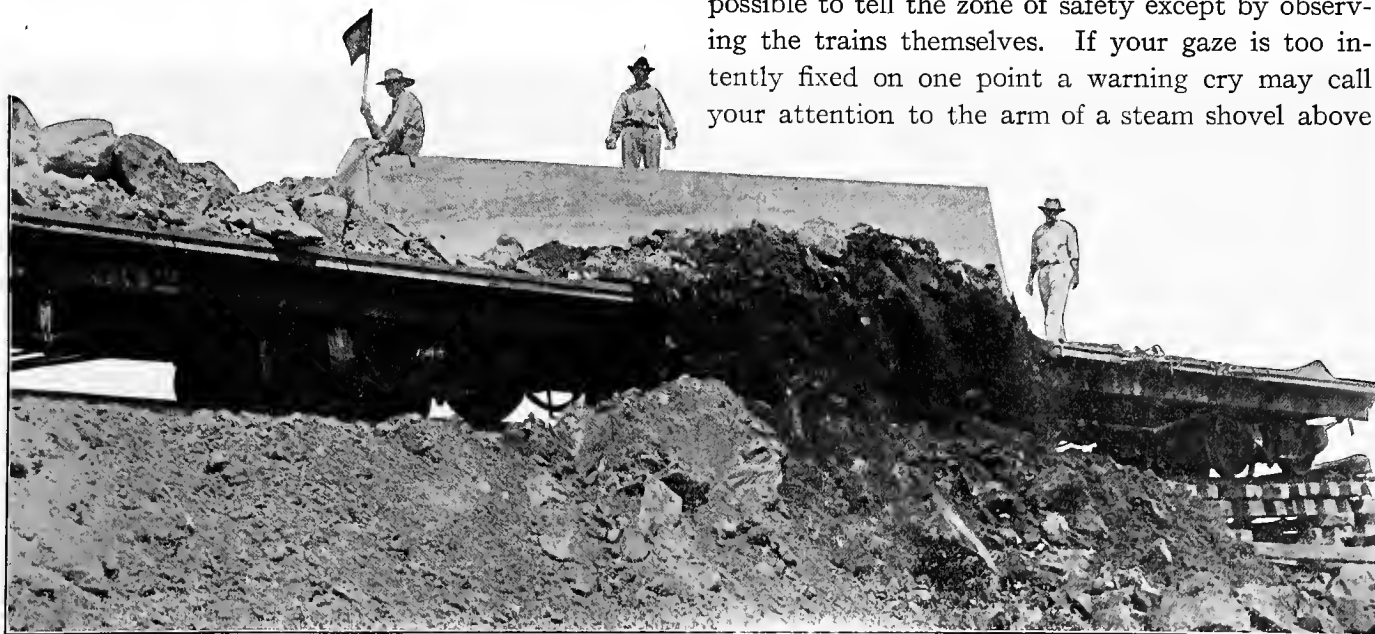


Photo by Underwood & Underwood

A LIDGERWOOD UNLOADER AT WORK

your head with a five-ton boulder insecurely balanced, or a big, black Jamaican a few yards ahead perfunctorily waving a red flag in token that a "dobe" blast is to be fired. A "dobe" blast is regarded with contempt by the fellows who explode a few tons of dynamite at a time and demolish a whole hillside, but the "dobes" throw fifty to one hundred pound stones about in a reckless way that compels unprofessional respect.

They tell a story on the Zone of a negro who, not thinking himself in range, was sitting on a box of dynamite calmly smoking a cigarette. A heavy stone dropped squarely on his head killing him instantly, but was sufficiently deflected by the hardness of the Ethiopian skull to miss the box on which the victim sat.



ONE OF THE COLONEL'S TROUBLES

This shovel was overwhelmed by a slide. The accident is not uncommon

Three hundred and twenty trains in the eight-hour day, with two hours' intermission at noon, means almost one train a minute speeding through a right of way 300 feet wide and much cluttered up with shovels, drills and other machinery. In March, 1911, the record month, these trains handled 1,728,748 cubic yards of material, carrying all to the dumps which average 12 miles distant, the farthest one being

Had it been otherwise the neighboring landscape and its population would have been materially changed.

It is no wonder that we have trains to dodge during the course of our stroll. There are at the moment of our visit 115 locomotives and 2000 cars in service in the Cut. About 160 loaded trains go out daily, and, of course about 160 return empty.

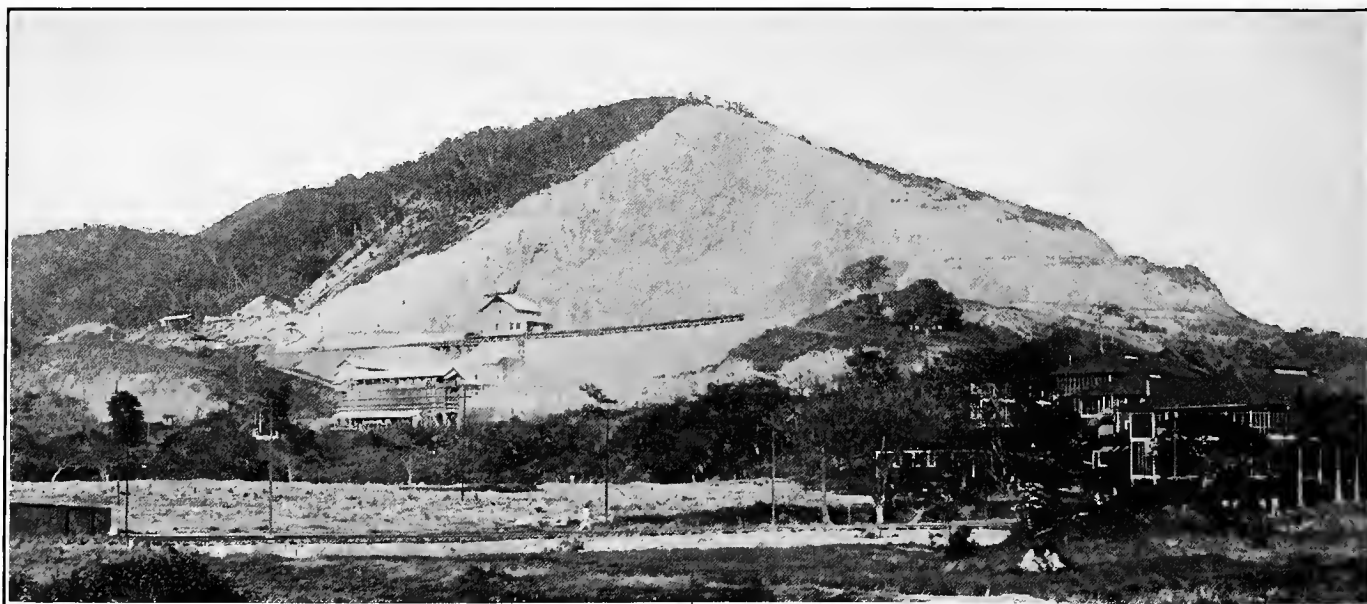


Photo by Underwood & Underwood

THE SLICED-OFF HILL AT ANCON



Photo by S. H. Elliott

A LOCK-CHAMBER FROM ABOVE

33 miles. The lay mind does not at first think of it, but it is a fact that it was no easy task to select spots for all this refuse in a territory only 436 square miles in area, of which 164 square miles is covered by Gatun Lake and much of the rest is higher than the Cut and therefore unsuited for dumps. The amount of material disposed of would create new land worth untold millions could it have been dumped along the lake front of Chicago, or in the Hackensack meadows near New York.

To load these busy trains there were in the Cut in its busiest days 43 steam shovels mainly of the type that would take five cubic yards of material at a bite. One load for each of these shovels weighed 8.7 tons of rock, 6.7 tons of earth, or 8.03 tons of the "run of the Cut"—the mixed candy of the Culebra shop. March 11, 1911, was the record day for work on the Central Division of which the Cut is the largest component part. That day 333 loaded trains were run out and as many in, and 51 steam shovels and 2 cranes with orange peel buckets excavated 127,742 tons of material. It was no day for nervous tourists to go sight-seeing in the Cut.

Let us watch one of the steam shovels at work. You will notice first that it re-

quires two railroad tracks for its operation—the one on which it stands and one by the side on which are the flat cars it is to load. If the material in which it is to work is clay or sand, the shovel track is run close to the side of the hill to be cut away; otherwise the blasters will have preceded it and a great pile of broken rock lies by the side of the track or covering it before the shovel. Perched on a seat which revolves with the swinging arm a man guides the great steel jaws to the point of excavation. A tug at one lever and the jaws begin to bite into the clay, or root around in the rock pile until the toothed scoops have filled the great shovel that, closed, is rather bigger than a boarding house hall bedroom. A tug at another



WHEN THE OBISPO BROKE IN

lever and they close. A third lever causes the arm to swing until it comes to a stop above the flat car, then with a roar and a clatter the whole load is dumped. Perhaps then the trouble is just beginning. Once in a while a boulder of irregular shape rolls about threatening to fall to the ground. With almost human intelligence the great

trained elephants pile teak lumber, pushing with tusk and pulling with trunk until the beams lie level and parallel to an inch. But marvelous as is the delicacy with which the unwieldy animals perform their work, it is outdone by the miraculous ingenuity with which the inventive mind of man has adapted these monsters of steel to their appointed



Photo by Underwood & Underwood

UNGAINLY MONSTERS OF STEEL WORKING WITH HUMAN SKILL

rigid arm of the shovel follows it, checking it as it approaches the edge of the car, pushing it back, buttressing it with other stones, so that when the train gets under way it may by no chance fall off. Sometimes you see all this done from a point at which the directing man is invisible and the effect is uncanny.

Travelers in Burmah are fond of telling how the

task. We shall see on the Zone many mechanical marvels, but to my mind the sight of a man, seated placidly in a comfortable chair, and with a touch on levers making a twenty foot steel arm, with a pair of scoops each as big as a hogshead at the end, feel up and down a bit of land until it comes upon a boulder weighing five tons, then pick it up, deposit it on a flat car, and block it around with smaller

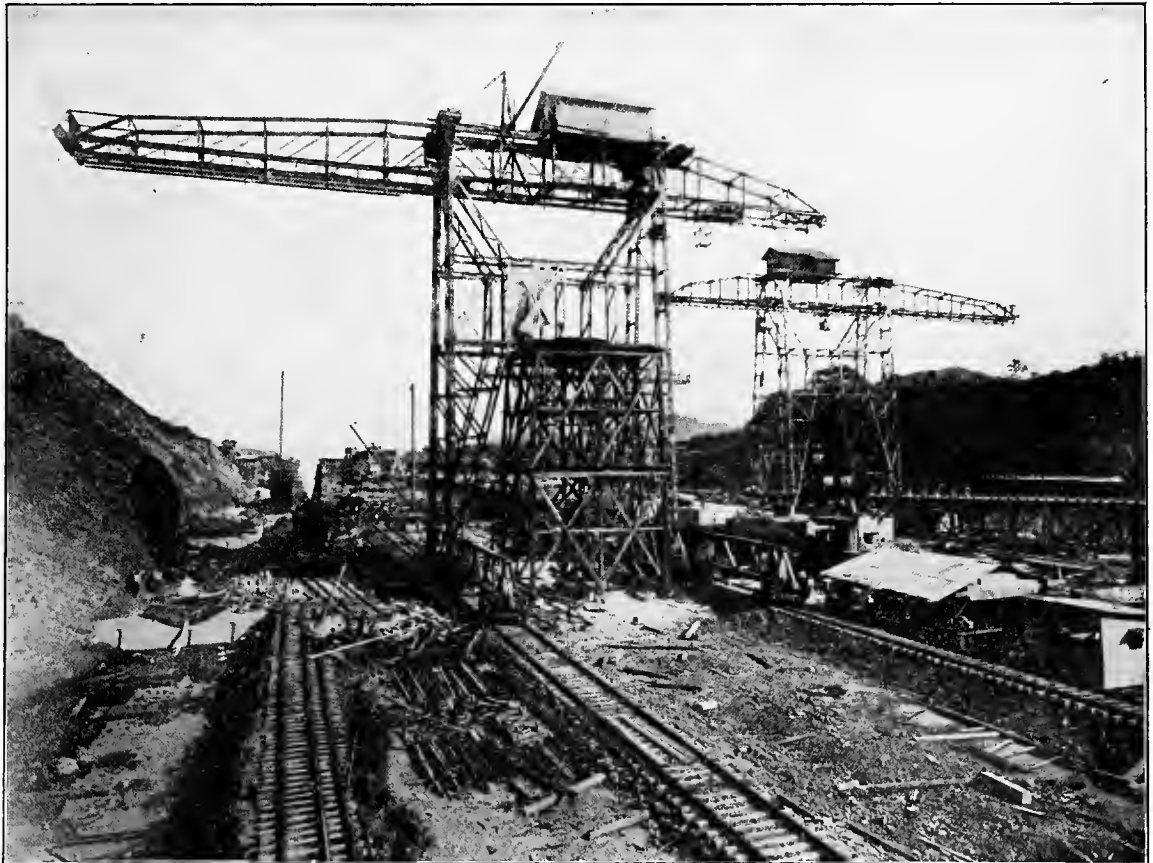




BUILDING AN UPPER TIER OF LOCKS

stones to hold it firm—this spectacle I think will rank with any as an illustration of mechanical genius. It is a pity old Archimedes, who professed himself able to move the world with a lever if he could only find a place for his fulcrum, could not sit a while in the chair of an Isthmian steam shoveler. These men earn from \$210 to \$240 a month and are the aristocracy of the mechanical force in a society where everybody is frankly graded according to his earnings. They say their work is exceedingly hard upon the nerves, a statement which I can readily credit after watching them at it. Once in

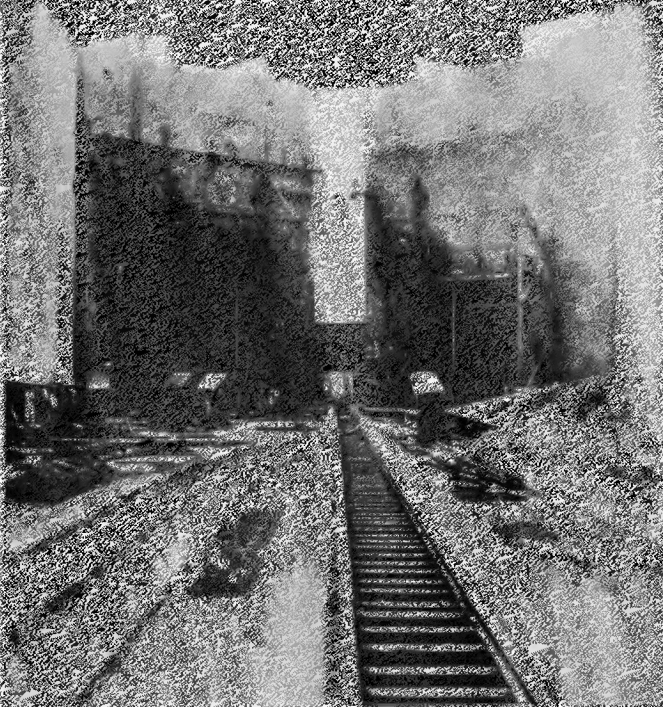
a great while they deposit the six-ton load of a shovel on top of some laborer's head. Incidents of this sort are wearing on their nerves and also upon the physique of the individual upon whom the burden has been laid. On several occasions I timed steam shovels working in the Cut on various sorts of material and found the period occupied in getting a load, depositing it on the car and getting back into position for another bite to be a fraction less than two minutes. According to my observations from five to eight shovel loads filled a car. The car once filled, a big negro wig-wagged the tidings to the engineer who pulled the train ahead the length of one car. The Jamaica negro wig-wagging is always a pleasing spectacle. He seems to enjoy a job as flagman which gives from five to fifteen minutes of calm reflection to each one minute of wagging. Far be it from me to question the industry of these sable Britons by whom the Canal is being built. Their worth in any place, except that of waiters at the Tivoli Hotel, must be conceded. But their specialty is undoubt-



TRAVELING CRANES THAT BEAR THE BRUNT OF BURDEN CARRYING

edly wig-wagging.

If we climb upon one of the empty flat cars we will see that upon the floor of the whole train, usually made up of about 20 cars, is stretched a stout cable attached to a heavy iron



In the early days of the work this business of shifting tracks required the services of hundreds of men. But it grew so steadily under the needs of the service—they say the Panama Railway runs sideways as well as lengthwise—that the mechanical genius of American engineers was called into play to meet the situation. Wherefore behold the track-shifter, an engine operating a long crane which picks up the track, ties, rails and all, and swings it to one side three feet or more according to the elasticity of the track. It takes nine men to operate a track shifter, and it does the work which took 500 men pursuing the old method of pulling spikes, shifting ties and rails separately and spiking the rails down again. It is estimated that by this device the government was saved several million dollars, to say nothing of an enormous amount of time. While the Panama Railroad is only 47 miles long it has laid almost 450 miles of rails, and these are con-

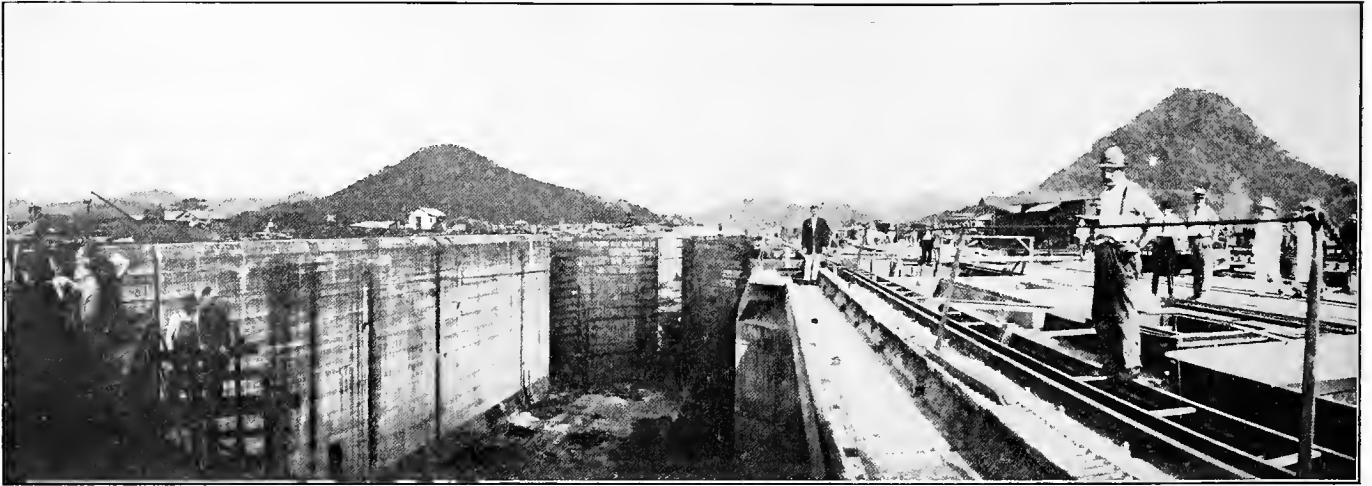
tinually being taken up and shifted, particularly those laid on the bed of the Canal in Culebra Cut. It is perfectly clear that to keep the steam shovels within reaching distance of the walls they are to dig away, the track on which they operate and the track on which their attendant dirt trains run must be shifted laterally every two or three days.

Looking up from the floor of the Canal one had in those days of rushing construction a prospect at once gigantic, brilliant and awe inspiring. Between Gold Hill and Contractors Hill the space open to the sky is half a mile wide and the two peaks tower toward the sky 534 feet to the one side and 410 on the other. We see again dimly through the smoke of the struggling locomotives and the fumes of exploding dynamite the prismatic color of the stripped sides of the hill, though on the higher altitudes untouched by recent work and unscarred by slides the tropical green has already covered all traces of



Photo by Underwood & Underwood

A STEAM SHOVEL IN OPERATION



BIRD'S EYE VIEW OF THE MIRAFLORES LOCKS

man's mutilations. In time, of course, all this coloring will disappear and the ships will steam along betwixt two towering walls of living green.

One's attention, however, when in the Cut is held mainly by its industrial rather than by its scenic features. For the latter the view from above, already described, is incalculably the better. But down here in the depths your mind is gripped by the signs of human activity on every side. Everything that a machine can do is being done by machinery, yet there are 6000 men working in this narrow way, men white and black and of every intermediate and indeterminate shade. Men who talk in Spanish, French, the gibberish of the Jamaican, in Hindoo, in Chinese. One thinks it a pity that Col. Goethals and his chief lieutenants could not have been at the Tower of Babel, for in that event that aspiring enterprise would never have been halted by so commonplace an obstacle as the confusion of tongues.

To us as we plod along all seems to be conducted with terrific energy, but without any recognizable plan. As a matter of fact all is being

directed in accordance with an iron-clad system. That train, the last cars of which are being loaded, on the second level must be out of the Cut and on the main line at a fixed hour or there will be a tie-up of the empties coming back from the distant dumps. That row of holes must be drilled by five o'clock, for the blast must be fired as soon as the Cut is emptied of workers. The very tourists on the observation car going through the Cut must be chary of their questions, for that track is needed now for a train of material. If they are puzzled by something they see, it will all be explained to them later by the guide in his lecture illustrated by the working model at the Tivoli Hotel.

So trudging through the Cut we pass under a slender foot bridge suspended across the Canal from towers of steel framework. The bridge was erected by the French and will have to come down when the procession of ships begins the passage of the Canal. Originally its towers were of wood, but a man idly ascending one thought it sounded hollow beneath his tread and, on examination, found the interior



THE ROCK-BREAK THAT ADMITTED THE BAS OBISPO

had been hollowed out by termite ants leaving a mere shell which might give way under any unaccustomed strain. This is a pleasant habit of these insects and sometimes produces rather ludicrous results when a heavy individual encounters a chair that has engaged their attention.

The activity and industry of the ant are of course proverbial in every clime, but it seems to me that in the Isthmus particularly he appears to put the sluggard to shame. As you make your way through the jungle you will now and again come upon miniature roads, only about four inches wide it is true, but vastly smoother and better cleaned of vegetation than the paths which the Panamanians dignify with the name of roads. Along these highways trudges an endless army of ants, those going homeward bearing burdens of leaves which, when buried in their subterranean homes, produce fungi on which the insects live. Out on the savanna you will occasionally find a curious mound of hard dirt,

sometimes standing taller than a man and rising abruptly from the plain. It is an ant's nest built about a shrub or small tree, which usually dies off so that no branches protrude in any direction. A large one represents long years of the work of the tiny insects. Col. Goethals has made a great working machine of the Canal organization but



A TERMITE ANT'S NEST
The ants' work kills the tree



Photo by H. Pittter. Courtesy National Geographic Magazine

AN ANT'S NEST ON THE SAVANNA

he can teach the ants nothing so far as patient and continuous industry is concerned.

We come in due time to the upper entrance of the Pedro Miguel lock. Here the precipitous sides of the Canal have vanished, and the walls of the lock have in fact to be built up above the adjacent land. This is the end of the Central Division—the end of the Culebra Cut. The 8.8 miles we have left behind us have been the scene, perhaps, of the most wonderful exercise of human ingenuity, skill and determination ever manifested in any equal space in the world—and I won't even except Wall Street, where ingenuity and skill in cutting things down are matter of daily observation. But nowhere else has man locked with nature in so desperate a combat. More spectacular engineering is perhaps to be seen on some of the railroads through our own Sierras or on the trans-Andean lines. Such dams as the Roosevelt or the Shoshone of our irrigation service are more im-



DEEP SEA DREDGE AT BALBOA

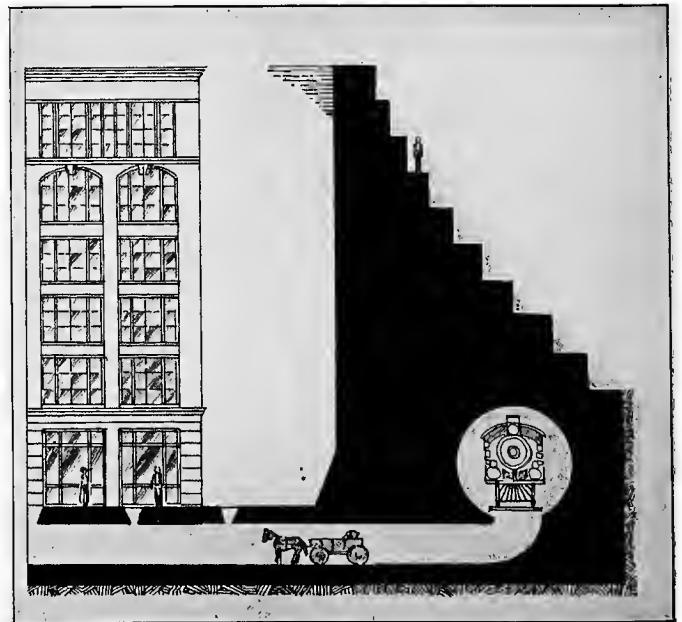
pressive than the squat, immovable ridge at Gatun. But the engineers who planned the campaign against the Cordilleras at Culebra had to meet and overcome more novel obstacles, had to wrestle with a problem more appalling in magnitude than any that ever confronted men of their profession in any other land or time.

As no link in a chain is of less importance than any other link, so the Pacific Division of the Panama Canal is of equal importance with the other two. It has not, however, equally spectacular features. Its locks at Pedro Miguel and at Miraflores are merely replicas of the Gatun locks with different drops, and separated into one step of two parallel locks at the former point, and two steps, with four locks in pairs at Miraflores. Between the two locks is an artificial lake about 54 2-3 feet above sea level and about a mile and a half long. The lake is artificial, supplied partly by small rivers that flow into it and partly by the water that comes down from the operation of the locks above. In fact it was created

largely for the purpose of taking care of this water, though it also served to reduce somewhat the amount of dry excavation on the Canal. One advantage which both the Gatun and Miraflores lakes have for the sailor, that does not at first occur to the landsman, is that being filled with fresh water, as also is the main body of the Canal, they will cleanse the bottoms of the ships passing through of barnacles and other marine growths. This is a notable benefit to ships engaged in tropical trade, for in those latitudes their bottoms become befouled in a way that seriously interferes with their steaming capacity.

The name Pedro Miguel is given to this lock because the French began operations there on the feast day of St. Peter Michael, whose name in Spanish is applied to the spot. An omniscient gentleman on the train once assured me that the name came from a Spanish hermit who long lived on the spot in the odor of sanctity—and divers other odors if the haunts of the

hermits I have visited elsewhere were any criterion.



PROPORTIONS OF THE LOCKS

A six story building would stand in the lock-chamber. Size of conduits indicated by small sketches of wagon and locomotive.

Errors of fact, however, are common on the zone. They still laugh about a congressman who, on Gatun dam, struck an attitude and exclaimed with feeling—"At last then I stand in the far-famed Culebra Cut"! which spot was a trifle more than thirty miles away.

From the lower lock at Miraflores the canal describes a practically straight course to the Pacific Ocean at Balboa, about $4\frac{1}{2}$ miles. The channel is continued out to sea about four miles further. All the conditions of the Pacific and Oriental trade give assurance that at Balboa will grow the greatest of all purely tropical ports. To it the commerce of the whole Pacific coast of North America, and of South America as far south at least as Lima, will irresistibly flow. To it will also come the trade of Japan, Northern China and the Philippines, seeking the shortest route to Europe or to our own Atlantic coast. It is true that much of this trade will pass by, but the ships will enter the Canal after long voyages in need of coal and in many cases of refitting. The government has anticipated this need by providing for a monster dry dock, able to accommodate the 1000 foot ships yet to be built, and establishing repair shops fit to build ships as well as to repair them. In 1913, however, when this trip through

the Canal under construction was made, little sign of this coming greatness was apparent. The old dock of the Pacific Mail and a terminal pier of the Panama Railroad afforded sufficient dockage for the steamships of which eight or ten a week cleared or arrived. The chief signs of the grandeur yet to come were the never-ceasing dirt trains rumbling down from Culebra Cut and discharging their loads into the sea in a great fan shaped "fill" that will afford building sites for all the edifices of the future Balboa, however great it may become. Looking oceanward you see the three conical islands on which the United States is already erecting its fortifications.

Here then the Canal ends. Begun in the ooze of Colon it is finished in the basaltic rock of Balboa. To carry it through its fifty miles the greatest forces of nature have been utilized when possible; fought and overcome when not. It has enlisted genius, devotion and sacrifice, and has inflicted sickness, wounds and death. We can figure the work in millions of dollars, or of cubic yards, but to estimate the cost in life and health from the time the French began until the day the Americans ended is a task for the future historian, not the present-day chronicler.



THE GREAT FILL AT BALBOA WHERE THE CULEBRA SPOIL IS DUMPED