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## Story of the Panama Canal By the Man Who Built It

Now It Is Finished, Col. Goethals Tells How It Will Be Used and Defended.

More than 95 per cent. of the ves-

protection of the intermediate gates

Guide piers are provided both

Even with an these precautions ac-

cidents may happen, and emergency

dams are provided at the head of each

flight of locks, consisting of swing

Duplicate Locks.

consisted of the construction of dupli-

cate locks at Pedro Miguel, overcom-

In the Pacific division the work

PART III.

BY COL. GEORGE WASHINGTON GOETHALS,

Corps of Engineers, United States Army, Chairman and Chief Engineer Isthmian Canal Commission.

(Copyrighted, 1913, by the Newspaper Enterprise Association in the United States, Great Britain, France and Germany.)

An earth dam across the Chagres at | ble of checking a ship of 10,000 tons Gatun impounds the water of the river moving at the rate of five miles an divisions, and special investigations. and creates the lake which constitutes the highest level of the Panama Canal. measured along the top. It is 2,100 than 600 feet in length, and this has feet wide at the base, 308 feet through been taken as the determining factor at the water surface, and 100 feet wide for the location of intermediate gates, at the top, which is 115 feet above sea which are introduced in the design to level. It crosses two valleys separated save both time and water. For the

The dimensions of the dam have against vessels using a smaller length been criticised as excessive and un- of chamber a chain barrier is to be inwarranted, but its designers consid- stalled. ered it desirable, in view of the amount of material available, that ample pro- upstream and down, to which vessels visions be made against every force will the before entering the locks. which may affect its safety, and that Electric towing machines will be used a barrier be made so that the layman, for towing vessels into and controlling without engineering knowledge, would their passage through the locks by recognize its stability. It extends from means of lines or cables attached to the hill in which the locks are con- what may be considered the four corstructed to Spillway Hill, thence along ners of the ship. the spur or hog-back of the hill on the west side of the valley.

Locks Are in Pairs. The locks are in pairs, so that if any lock is out of service navigation will bridges, which can be thrown across not be interrupted. Thus, also, when the locks in case of an accident which all the locks are in use, the passage of makes a connection between the top shipping will be expedited by using one level and the level below; wicket girdother for the descent. The locks are bridges, supported by a sill at the bot-110 feet wide and have usable lengths tom and the horizontal truss work of and this is still retained as the date tubes, and the problem was success-

The system of filling adopted con- girders act as runways for grates, sists of a culvert in each side wall which are lowered and gradually stop feeding laterals perpendicular to the the flow. axis of the lock, from which are openings upward into the lock chamber. This system distributes the water as evenly as possible over the entire horizontal area of the lock and reduces ing a 30-foot difference of level, with the disturbance in the chamber when the necessary dams; two locks in the latter is being filled or emptied.

The middle or separating wall contains a single culvert of the same one earth and one concrete dam; exarea as the culverts in the side walls, cavating the channels between the which feeds in both directions through locks to the required depths, and the laterals controlled by valves designed excavation of the channel to proper to operate against a head from either width to deep water in the Pacific. direction. This arrangement permits The Miraflores locks are two in communication between the chambers flight, overcoming the difference of twin locks, so that water may be level between Miraflores Lake and the passed from one lock to the other of sea level section. the pair, effecting a saving of water. for these locks is about 65 feet.

uates and 51 seconds when both culverts are used.

type, double leaf, straight gates, varying in height from 45 feet 7 inches to 79 feet; the length of each leaf is about 100 feet; the length of each l

Guarding the Gates. It has been accepted as a fundalevel from the level next below. at the lower end of each of the uppermost locks in each flight.

to guard the barrier gates against ac- resulted.

ed into three divisions. The first had trouble was. charge of designs of masonry and lock structures, including valves, lock gates chinery, movable dams and spillway. ing stations, of all questions that arose mprovements, estimates, allotment of through safety values; but it was a funds, rates of pay and cost keeping. The third had charge of meteorology, hydraulics, general surveys not pertaining to any of the construction

Reporting directly to the chairman The dam is 7,500 feet long over all, sels navigating the high seas are less sanitation, civil administration, law, examination of accounts, disbursements, the quartermaster's and subsistence departments, and the purchasing department in the United States.

Generally speaking, employees were selected on account of their special fitness for the work in hand and were then unhampered in their methods of securing definite results, thus bringing out to its fullest extent individual effort and brain power. As a consequence each man had a personal interest in each man had a personal interest in off the charge without standing close the work and seemed imbued with the to the machine. My wife and I made to the machine. depended on him. The spirit of enthusiasm and of loyalty among the canal workers strikes forcibly every one who visits the Isthmus and convinces the doubting how the canal was built.

and a learner explosion fortowed. One piece of the machine came out at the door and was imbedded in the barrier that protected us.

How Defect Was Remedied.

Nine Years To Build.

the bridge at the top. These wicket for the official opening.

Much has been said and predicted as Isthmian Canal, and had the canal been the station that there had been an built at that time, thereby saving the explosion. It was my torpedo apparatus flight, also in duplicate, at Miraflores. connected with the adjacent hills by trip around the Horn, there is no that had exploded. It was in charge of

with facilities for fully equipping, sup- shop was burned. ama route would offer many advan-tages and bring to it a sufficiently re-safety delayed-action fuse, since toppling her sufficiently to get my plying and repairing ships, the Panthe operating expenses, but to gradu- the service detonating fuse for high package away from her bulk by throwemptied, using one culvert, in 15 pushed forward so as to keep pace with ally absorb the debt which the United explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles. I had some full line the weight of my body against her explosive projectiles.

was outhorized to construct a canal It has been asserted in many quarthellock gates are of the mitering through a commission consisting of ters that the locks might be destroyed faulty organization. In 1907 the Presi- the locks it would be necessary to place dent simplified matters by combining the charge very carefully in them. To the duties of chairman and chief en- do that would take time, and what mental feature of the design that at gineer in one person, and later the would our men be doing in the meaneach flight of locks there must always Secretary of war vested the powers of time? One man could not carry a sufbe two barriers separating the high the governor of the Canal Zone in the ficient quantity to destroy the locks. To same party, thus eliminating the fric- You would have to locate the charge carry this out, two sets of mitering tion that had previously existed be- behind a gate and in a certain place gates are placed at the upper and two tween these three functionaries. Au- behind the gate in order to disable the thority was still further concentrated canal, and you must destroy the gates by an executive order in January, 1908, to destroy the canal. I cannot imagine In addition, a chain device is used and out of which the final organization what people operating the canal and the men having charge of its defence

around him while he stirred the nitroglycerine, as cool and calm as though it were the proper place for him to do

I made the first motorite in round bars and got them the proper size by stuffing them through a die. These rods of motorite were then varnished and sealed into steel tubes, so that when the rod was ignited on one end it could not fire down the side of the rod, but must be consumed from the exposed end only.

These rods, as I discovered later, contained longitudinal flaws, which were too small to be seen by the naked eye but which permitted the flame to enter under pressure and cause an explosion. Several of them exploded at the wrong time before I found out what the

When I made the first test on the material the first two rods went off and protective devices, operating ma- in the way I expected. The third exploded with the noise of a ten-inch The second had charge of the designs gun., There were three of us near it, and construction of drydocks and coal- and we all thought it was the end for us. We found that the machine itself concerning shops, buildings, municipal had not exploded, but had blown out

close call for us. Repeating the test, after making many changes in the machine and the explosive that I thought would remedy the danger, I was almost done for again. This time a young Irishman were the heads of the departments of and myself stoo near the machine. I asked him if he were afraid to stay. He answered not if I was not—and the button was touched and a terrible bang. The machine was blown to fragments, which were hurled in all directions around the room, some of them going through the walls. The windows were blown out, sash and all, but, fortunately, the young Irishman and my-

self escaped injury. The next time I made the test it was in a specially constructed shop, ldea that the success of the enterprise the test alone. The button was pressed and a fearful explosion followed. One

The test showed me the trouble and was able to remedy the longitudinal The time required for completing the flaws down the tube. I thereafter made lock type of canal was estimated by my tubes from circular disks cut from the board of 1905, which made its re- sheets of the material and sealed them port in January, 1906, at nine years, together, building up the rods in that set of locks for the ascent and the ers are let down from these swing in accordance with which the work fashion. These rods were then made should be completed by Jan. 1, 1915, smooth, varnished and sealed into steel

Another case of not being on the to the commercial value of the canal ground when an explosion took place to the United States. In this connec- was when, in the midst of my extion it must be remembered that the periments on a torpedo apparatus, I commercial shipping of this country was called to Morristown, N. J., from never required the canal. The trip of my home at Lake Hopatcong, as an the Oregon in 1898 settled the question expert in a case being tried in court. of the advisability of constructing an When I returned home I learned at question that it would have been an experienced explosives man and I agreed generally that the canal, even could not understand how the accident at an expenditure of \$375,000,000, was had happened. Had I been there it might have happened just the same. With properly regulated tolls, and The explosives man was killed and the

Some time ago I was conducting exmunerative return to pay not only for adopted by the United States navy as toppling her sufficiently to get my States has incurred by its constructured minate detonators made at the torpedo shoulder. Then I removed the package station of the navy and received that they had been received and were down being held for me at Fort Lafayette. I was told to go to the Brooklyn navy

Takes Trolley to Save Time. I procured the package according to he directions given me, but when I had it I concluded I could save time by going home by trolley car instead of by tug via the Brooklyn navy yard. It was prefectly safe to carry the fulminate detonators if handled in an ordinarily careful manner. Of course it would not do to jump or kick around, for in that case there would be sudden and surprising results.

I found a seat on the trolley car and out the package alongside of me. kept my eye constantly upon it to see that it did not fall off the seat and

that no one touched it. I had scarcely arranged things to my satisfaction when a huge, determined woman entered, brushing he aisle aside. She discovered the small space occupied by my package, and since all the seats were occupied she decided that she would take that one. She measured the distance with her eye, then turned and hurried herself backward and plunged downward She was so quick in her movements

Baking Baking

### Old Dutch Cleanser

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left arm out to protect the package. am unusually strong, but I had all I ould do to support her enormous

bulk. When she felt my arm beneath he protecting the package she was all the more indignant and determined to crush the package in order to teach me a lesson. She said not a word, but

Fate Missed by Angry Woman. She did not know what she missed nor did the other passengers in the car, but it is safe to say that she would have arisen more rapidly than she sat down had her bulk been allowed to descend on the package of fulminate

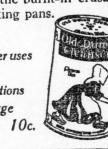
detonators. The package was not a particularly large one, but there was enough high explosive in it to wreck the car, and while some of the people in it would have escaped they would have been ucky. There was absolutely no danger carrying it that way except for the militant lady who was ready willing to do anything to secure what she thought were her rights.

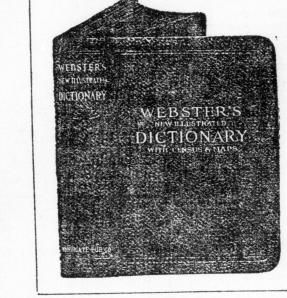
I never permit myself to write verses to ladies when I know they will not be gratefully received, but in this instance I decided to break my rule. Taking my notebook from my pocket wrote the following, which I folded up few small men who were standing in carefully, and when the car reached my street I handed the folded paper to the militant one just before I alight. ed from the car:

> "Dear Madam: I'm an anarchist, That package was a bomb. I'm on my way Some one to slay,

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I didn't want to waste that bomb On just the likes of you.'

No doubt she was surprised to get this missive, and may have put the police on my trail as a dangerous

"The sports make both ends meet, all right." "How?" "Using headwork in football games."-Judge. "So Miss Biffers is married at last." "Yes." "And who is the happy man?" "Her dear old dad."-Birmingham Age.

# The chief engineer's office was divid- would be doing in the meantime. EXPERIENCE OF HUDSON MAXIM, INVENTOR

Noted Expert in Explosives Relates of Narrow Escapes From tinguished by the expansion of the Being Blown to Atoms While He Was Making Experiments-Once Saved From Death by Aid of Wife.

come the closest to meeting his fate. acts become automatic, and therefore A hair's breadth one way or another would have settled his combat with death; but there is a varying thick- or not. And sometimes he has notness in hairs, just the same as there is in all earthly things.

Some men think they have been nearer death because they missed a train that was wrecked, or were stopped by either physical or intuitive means from passing over a bridge that was destroyed just as they would been on it, or were kept from a building that was burned. I have had close calls

business of inventing and handling high explosives-to which I have devoted many years of my life. Some of these close calls seemed closer than the proverbial hair's breadth, while others were more or less of the negative kind, like being prevented by some outside circumstance from going where I would have met death.

The greatest source of danger working with explosive compounds not the conscious carelessness of the worker, who becomes accustomed to the danger of the compounds and the risk in handling them, but is due to

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No man really knows when he has the fact that many of the voluntary unconscious. When an act becomes unconscious a man does not really know at times whether he has performed i blown to pieces.

Hand Lost by Carelessness. It was such an unconscous act that

caused me to have my left hand blown off at the wrist when I was experimenting with fulminate of mercury compound. I was trying out this explosive one of the most dangerous and deadly known to science-when I forgot to the nitroglycerine makers placed there take a slight precaution and the com- to warm. She said he returned frepound exploded. It was a close call quently to stir the substance. for me and I might just as easily have been killed.

At another time when I was experimenting with this same compound film of water upon the top. My wife one of my assistants was weighing out some of this dangerous material in the laboratory. An iron weight fell from the arms supporting the scoop of the scales, striking less than an inch from the fulminate of mercury. Had the iron struck the explosive I would not be here writing of that close call. There were ten pounds of the compound in a jar standing on the bench, and ten pounds of that explosive can perform wonders in the way of des-

troying men and material close to it. The fact was that one time I could not find a suitable vessel to put dry guncotton in for an experiment I was making saved my life. I was delayed from going to the guncotton storehouse while a vessel was being cleaned for me to bring the explosive back in. While I was waiting the storehouse

Closest Calls With Motorite. Taking it all in all, however, I think the closest calls I have had were in my experiments with motorite. Motorite is a compound consisting of about 70 per cent. nitroglycerine and 30 per cent, guncotton, which is combined with the nitroglycerine, forming a somewhat rubbery substance. Motorite the exposed surface, like a piece of celluloid, only with greater rapidity than that substance. When it is burned no money, but tell others of than that substance. When it is burned in a confined space the rapidity of combustion increases directly with the pressure. If the container explodes from the pressure the motorite which

Motorite does not require air support its combustion and will burn under water. It is used as a fuel to evaporate water for steam by mixing the water and the flame together. When I first made this material had many narrow escapes from death. They were of both the positive and negative kind.

Of the negative kind was the care lessness of an old nitroglycerine maker who, with an assistant, was helping me. The weather was cold and there was a roaring fire in one of the houses in a big barrel stove. My wife, who was with me, kept warm by this fire. Danger Averted by Wife. It was due to her that the danger was removed. She called my attention

to a big pail full of a suspicious looking substance, which she said one of casionally a spark would crackle out from the fire into the pail. The spark would be extinguished by a very thin concluded that it might be dangerous if the substance happened to be nitroglycerine. She called my attention to t. It was nitroglycerine. The maker was scolded and the pail was removed. Ten minutes later, having occasion to visit the boiler-house, fifty feet distant, I discovered the maker with the same pail of nitroglycerine near the furnace. He had spread his body out between where the pail rested where the fireman was stirring up the

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