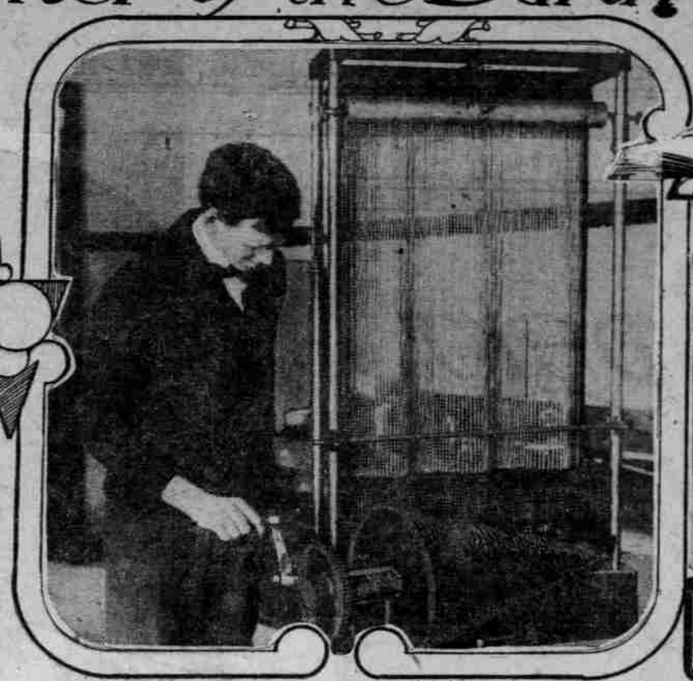
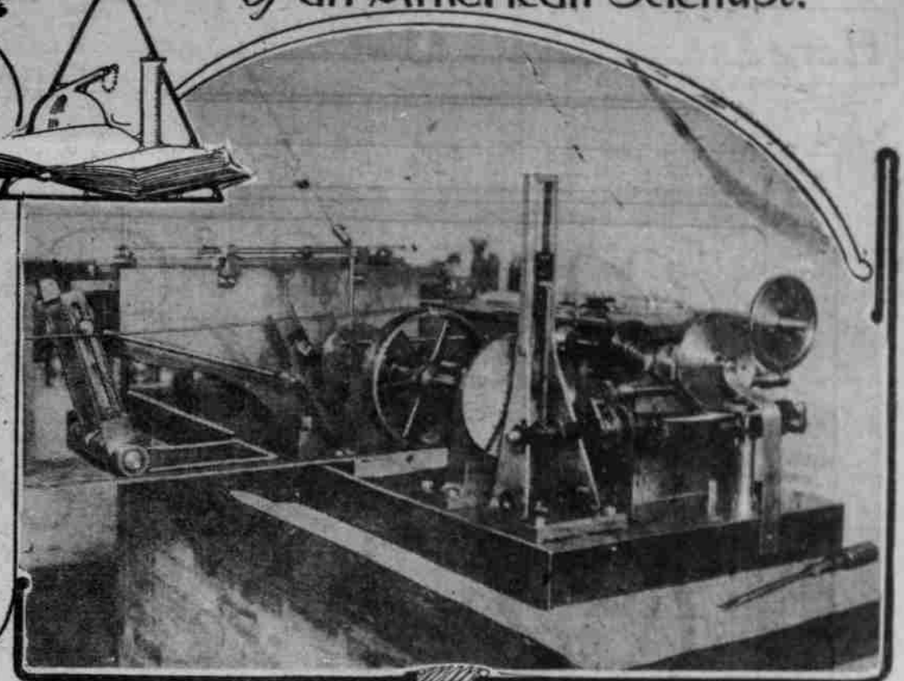
Exploring the Center of the Earth—

A Record of the Intricate Achievements of an American Scientist.

Albert Abraham Michelson in His Laboratory.



The Harmonic Analyzer.



Michelson's Ruling Engine.

BY ROBERT H. MOULTON.

THERE is a man in Chicago who can measure one-five millionth of an inch—a distance amounting to one-fiftieth of the smallest distance revealed by a theoretically perfect microscope. He can rule on a piece of polished glass, one inch wide, 50,000 straight, parallel lines, equally spaced.

He has determined the length of the standard meter so accurately that his figures cannot be subject to a fault exceeding more than one part in 2,000,000. He has measured the rate at which light travels with a possibility of error not more than one- fortieth of 1 per cent of the quantity measured—and light flies 186,330 miles a second—and, as a crowning achievement, he has determined the rigidity of the earth.

This man is the first American to receive the Nobel prize in science and the only American who has ever received the Copley medal of the Royal Society of London. Despite achievements that are staggering in their significance, this man's name is little known outside of scientific circles. He is Albert Abraham Michelson, Ph. D., Sc. D., LL.D., professor and head of the department of physics at the University of Chicago.

Professor Michelson's experiments to determine the rigidity of the earth are intensely interesting. Science has long needed to know the physical properties of this globe. It is impossible to learn this directly, as the deepest mines yet sunk penetrate less than two miles below the surface, a distance proportionately no greater than the thickness of the varnish on a two-foot globe. The interior of the earth is believed to be intensely hot. This theory is based on the fact that molten lava is thrown forth by erupting volcanoes. Also, in descending a mine, there is a rise in temperature, amounting to 50 degrees per mile of descent. If this rate of increase is constant, the temperature at only 100 miles down is above the melting point of all substances under conditions as they exist on the surface of the earth. However, despite the high temperature, the interior of the earth may be held in solid state by the tremendous pressure to which it is subjected.

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Under the now accepted theory of the celestial mechanics, scientists assume that a heavenly body is held in its course by the attractive force exerted by the other heavenly bodies on all sides of it. In this way is determined the earth's course around the sun and the motion of the entire solar system through space. Assuming that the earth is not a solid mass, scientists have long struggled to discover how it resisted the attractive forces exerted by other planets and stars—whether as a viscous mass or as a perfectly elastic body.

They have long known that the earth did resist these forces in some degree. The ocean tides which sweep our shores twice daily are proof of this. It has long been known that the tides are caused by the attraction of the sun and the moon. If the earth offered no resistance to this attraction, the whole earth would respond quickly to it and there would be no tides. On the other hand, if the earth were a perfectly rigid body, it would resist this attraction completely, and the tides would reach their maximum height. The amount that the tides fall short of their theoretical maximum height would measure the degree of rigidity which the earth possesses.

The next step was to determine the actual height of the tides. This long proved the stumbling block. If shore lines were perfectly straight and the floor of the ocean perfectly level, the height of the tides could be measured directly; but crooked shore lines and shelving beaches resist the motion of the tides and make it impossible to determine their height with the accuracy demanded by science.

Sir George Darwin made elaborate experiments to determine the height of the tides, but was obliged to give up the problem in despair. Professor Michelson solved this difficulty by laying two lengths of pipe, each 500 feet long, and measuring the rise and fall of the water in them. One length of pipe was laid north and south and the other length east and west, in order to measure the tides in both directions. The pipes were buried six feet under ground to obtain a uniform temperature.

At both ends of the pipes tees were inserted having glass windows for observatory purposes. The pipes were half filled with water; and the changes in the height of the water were obtained by measuring through a microscope the distance between a pointer inserted just under the surface of the water and the image of the pointer reflected above the water.

The maximum tides in these pipes did not exceed one-thousandth of an inch; but so perfect was the apparatus and so accurate the readings by Professor Michelson that all the variations in the tides were accurately determined. Tides are complex things. Their height varies with the position and distance of both the sun and the moon, and, therefore, is never the same two days in succession.

Professor Michelson's experiments revealed 39 of these variations, which corresponded almost exactly with the variations obtained theoretically by computing the variations in the attractive forces exerted by the sun and moon. The practical correspondence of the actual height of the tides with the theoretical height proved that the earth through and through is as rigid as steel and that it yields to outside forces as a perfectly elastic body and not as a viscuous mass.

This experiment reveals the imagination and the striking originality of Professor Michelson. The first achievement to bring his name to the attention of the scientific world was his accurate determination of the velocity of light, accomplished also after overcoming tremendous experimental difficulties. Light is the fastest thing in nature; it represents the absolute limit of speed. After four years of work and study, Professor Michelson announced that light travels with a velocity of 186,330 miles per second. The maximum error in this figure does not exceed one-fortieth of 1 per cent. The accuracy of this may better be judged when it is stated that, although light travels at a speed equivalent to more than seven times around the earth per second, the maximum error in Professor Michelson's figure does not exceed the distance a man could walk in a single day.

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On the subject of spectrum analysis, Professor Michelson has devoted many of the best years of his life. Spectrum analysis mg fg mb fg mb mfwypemfw analyses are obtained by means of the spectroscope. Every substance when heated emits a characteristic light. By means of the spectroscope this light is analyzed and the elements giving off the light are thereby revealed. The spectroscope has enabled scientists to determine the elements in far distant stars. It has made possible tremendously important discoveries concerning the nature of atoms, the minute particles of which all matter is composed.

The difficulties of spectrum analysis will be realized when it is learned that a single atom of sodium emits 800,000,000,000 vibrations per second of two slightly different kinds of light. Professor Michelson was engaged in spectrum analysis very long before he improved the spectroscope, calling the improved type an echelon spectroscope. This wonderful machine divides light into its various constituents and makes possible their separate analysis.

The echelon spectroscope uses a glass grating—a piece of highly polished glass on which is ruled from fifteen thousand to fifty thousand straight, equally spaced lines to the inch. To make these grating Professor Michelson invented a ruling engine that is the most accurately constructed mechanical device in the world. It is operated in a room the temperature of which is kept constant to within one-hundredth of a degree.

To assist in analyzing the lines of the spectrum into their fundamental constituents, Professor Michelson invented the "harmonic analyzer," a machine as complicated and as delicate as the linotype machine. By its use an assistant can in a few minutes make calculations that would take a skilled computer weeks to accomplish.

Scientists have long endeavored to determine the absolute motion of the earth through space. It is known that the earth swings around the sun and that the entire solar system is moving toward the constellation Hercules at the rate of 12 miles per second, or 400,000,000 miles per year. However, as scientists have not yet been able to measure the motion of Hercules, they still do not know the absolute motion of the earth. In 1880 Professor Michelson attacked the problem of determining the motion of the earth with reference to the ether, the all-pervading medium that fills interstellar space.

All of us have noticed that, when walking through the rain, although it is actually falling vertically, seems to be falling at an angle, the degree of this apparent deflection depending upon the speed with which we have moved. Looking out the window of a fast-moving train, scientists have noticed a similar deflection in the angle of the light coming to the earth from some far distant star. As the medium that carries the light between heavenly bodies is the ether, scientists argue that the deflection is due to the relative motion of the earth through the ether.

Professor Michelson eventually overcame the tremendous experimental difficulties in connection with this problem; but no motion of the earth with respect to the ether was found. This result came as a profound surprise to the entire scientific world. It does not mean that there is no motion relatively between the earth and the surrounding ether; but a number of basic scientific theories must be revised to account for this new condition.

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In order to solve this problem Professor Michelson invented a most marvelous instrument, which he called the "interferometer." This instrument is 50 times more powerful than an absolutely perfect microscope would be. The microscope's power is limited by the length of a light wave, and the smallest distance it can reveal is one-half a wave length, or one hundred thousandths of an inch. By utilizing the properties of light in another manner, the interferometer can reveal distances equivalent to one five millionths of an inch. The microscope has been of immense value both in scientific work and in practical life, and the invention of the interferometer, an instrument 50 times more powerful, is in itself an achievement that should win for Professor Michelson undying fame.

He used this instrument to aid him in measuring the standard meter, the foundation of the metric system, in terms of infinite exactitude and in a manner that will make this unit perpetual. The original meter length is carefully preserved at Paris; but scientists have long worried over the possibility of its destruction. In 1893 an international commission on weights and measures asked Professor Michelson to devise some method by which the meter length could be accurately reproduced. The meter is theoretically one forty-millionth of the earth's circumference; but this definition is not accurate enough for scientific purposes. Professor Michelson announced the length of the meter in terms of cadmium light waves, with a maximum error of one part in two millions. This definition will always enable scientists to reproduce the meter accurately, as long as cadmium light retains its properties—which is as long as the earth exists.

These are the most striking achievements of America's greatest scientist. Any one of them is sufficient to perpetuate a man's name in the annals of science. The result of Professor Michelson's experiments with reference to the motion of the earth has raised questions that it will take science many years to answer satisfacterily, and his determination of the rigidity of the earth has made possible further and more wonderful progress in the sphere of celestial mechanics.

SETTLING WITH BOGGS.

by Stephen Angus Cox.

A Claim Agent's Dangerous Interview and the Happy Thought That Prolonged It.

"HIGGINS," said the superintendent, "here is a claim. Go see the fellow and settle as cheaply as possible."

Robert Higgins, claim agent of the B. D. & S. Railroad, took the letter from the superintendent's hand, and read its contents, which were as follows:

Supt. B. D. & S. Railroad: Yore darn injine killed six uv my best steers. I want yuh to pay darn quick.

BEN BOGGS.

The letter bore the address of a whistling station up in the wildest region of Wyoming.

"All right," said Higgins, "I'll go out there and settle with Mr. Boggs."

That evening he took the train, and next morning he was at his destination, Rawlins, and, alighting from the cars, looked around him. It did not take very long to see all that was to be seen, for the place consisted of only one store, a hotel, two or three saloons, and about a dozen ramshackle houses.

Higgins interviewed the agent-operator and general man-of-all-work, and inquired about Boggs.

"He is a hard case," said the agent.

"Where does he live?"

"'Bout ten miles," motioning toward the east.

"H'm! He sent in a claim for damages for six steers that he says one of our trains killed. Know anything about it?"

"Only that if he had any steers he must have rustled 'em."

"Ah—he hasn't any stock of his own, then?"

"No; only what he steals."

"Did the train kill some steers that he claimed as being his?"

"Maybe so. I know a train killed five or six steers a couple of weeks ago. The section hands say Boggs drove the steers on to the track a little while before the train came along, though."

"That so? I guess I'll interview the section hands."

Higgins did so, and the men said that they had seen somebody drive the steers onto the track, and while they were so far away they could not be certain that it was Boggs, they did not have any doubt that it was he, as he had sent in the claim for damages.

Higgins then went to the hotel, where he registered, ate breakfast, and engaged the landlord in conversation. He told him about Boggs and his claim for damages for the steers, and the landlord shook his head.

"Boggs is a bad egg," he said. "He's a terror, a gun-fighter, an' if I was in your place I'd settle with him at his own figgers an' then hike out uv town afore he got full on the money an' wanted to be paid again."

"I'm not going to let him rob me, even if he is a desperado and gun-fighter," remarked Higgins quietly. "I can shoot a little myself," and he tapped his pocket significantly.

The landlord again shook his head and looked sober.

"He'd git yuh, I'm guessin'," he said. "I'd pay almost any amount in reason, an' not have any trouble with him."

"I wonder if he'll be in town today?" observed Higgins. "Or will I have to go out to his place?"

"He'll likely be in today. I'd wait here, if I were you."

"All right, I guess I will. The agent and the section hands tell me that Boggs drove the steers onto the track, anyhow; and the agent says likely they were rustled steers, and not his. So I'm not going to pay him very much for them."

"Better pay him a rather stiff price than hav' 'im put a bullet in yuh, Mr. Higgins," was the reply.

The claim agent shook his head grimly.

"We'll see about that," he said.

Higgins put in the day sitting around, smoking and waiting. He was out on the porch, about the middle of the afternoon, when he saw a huge, whiskered ruffian ride up in front of a saloon about a hundred yards distant, dismount and tie his horse. As he did so, the landlord, who had stepped to the door, said: "That's your man."

"I suspected as much," was the reply.

"Yes. How d'yuh like his looks?"

"He looks like he might be capable of shooting a man up."

"Yes, especially when he's drinkin'. If yuh take my advice yuh'll go an' have your settlement with him before he gets tanked up."

Higgins nodded.

"That's a good idea, I judge." Then he rose, stretched, and stepping off the porch, walked slowly toward the saloon.

When Higgins entered, Boggs was standing at the bar, engaged in the pleasing pastime of filling himself with bad whisky. He glanced at the claim agent, nodded, and said: "How air ye, stranger? The boys has jest been tellin' me that ye was in town. Glad ter see ye. Got ther money ter pay me fur them steers?"

"I guess so," was the reply, "that is if you don't want too much for them."

"Three hundred dollars is my price fur them steers, Mister—what's yer name?"

"Higgins."

"All right, Higgins. Jest hand out $300, an' take a drink with me, an' we'll call it squar'."

Higgins shook his head.

"Too much money, Mr. Boggs," he said. "I can't allow you $50 apiece for the steers. They weren't worth more than $10 or $15 each."

The face of the ruffian turned red with anger. He glared at the claim agent fiercely.

"What's that?" he cried. "D'ye mean to insult me, Mr. Higgins? Them steers was worth fifty dollars apiece, an' that's the price I'm goin' to get fur 'em, too, or I'll have blood, d'ye hear what I say, young feller?"

His hand dropped to the handle of his revolver, and the men in the room, who evidently knew Boggs well, sidled around so as to be out of range of his weapon. Higgins saw these actions, and knew that he was in danger, but he did not flinch.

He met the gaze of the fellow steadily, and advancing a couple of steps, leaned his elbow on the bar, and standing with his side half turned toward the man, said quietly:

"Don't get angry, Mr. Boggs. This is a business proposition, and there will be no occasion for the shedding of blood. Now, those steers were—"

"Them steers were worth three hundred dollars!" cried Boggs, thumping the bar viciously, "an' I'm goin' to have three hundred dollars fur 'em. So ye might as well pay me, furst as last."

"Be calm, Mr. Boggs," said Higgins quietly. "Let's talk this matter over. I'm willing to pay you a reasonable price for them, but—"

With an exclamation of anger and impatience, the ruffian jerked out his revolver and leveled it, the muzzle almost touching Higgins's forehead.

"I don't want talk," Boggs snarled. "I want money. Han' over thet three hundred, an' do it quick!"

Higgins knew that he was in great danger, but still he did not show signs of alarm.

"Be reasonable, Mr. Boggs," he replied. "Take that gun away. You might pull the trigger too hard, and—"

"Then et would be good-bye Mr. Higgins," was the grim retort. "An' I'm mighty apt to pull ther trigger ef ye don't dig up that three hundred purty prompt, d'ye hear?"

Higgins was doing some swift thinking. Boggs had the drop on him, and he realized that the desperado would not hesitate to shoot him down, as he threatened.

Still, he did not intend to pay three hundred dollars for the steers, which could not have been worth more than one hundred and twenty-five at the most. And he was trying to figure out how he was going to manage the affair.

Suddenly a thought came to him: He was an expert boxer, and although Boggs was 50 or 60 pounds heavier, Higgins believed he could give the ruffian a thrashing in a fair fist fight, so he said quietly:

"I'll tell you what I'll do, Boggs."

"What'll ye do?" gruffly.

"You want three hundred dollars for the steers?"

"Yes, an' I'm goin' to have—"

"I claim that the steers were worth a hundred dollars," interrupted Higgins, "but I'll make you this proposition: We will fight a fair and square fist fight, and if you whip me, I'll pay you the three hundred dollars; while if I whip you, I'll pay you only one hundred. Come, what do you say?"

"That I'll go ye," was the reply, with a chuckle. "W'y, Mr. Higgins, ye won't be in et at all with me. Ye might as well pay me the three hundred dollars an' be done with et."

He placed the revolver in his belt, and Higgins drew a breath of relief. He had feared that the fellow might pull too hard on the trigger in his anger, and that would have been the end of Higgins.

The idea of a fight between the two met with the approval of all the men present, and so the matter having been settled, all adjourned to the open air, where the principals doffed their coats and rolled up their sleeves ready for business. By the time they were ready to fight the entire population of Rawlins was on the ground, even to the landlord of the hotel and the station agent, there being no train due at that time.

The landlord acted as referee, and when they were ready, he told them to go at it. No sooner was the word given than Boggs rushed upon his smaller antagonist and made a fierce attack, but Higgins quickly sent him down for the count.

Exclamations of wonder and delight escaped the lips of the onlookers. They were amazed that Higgins, who was so much smaller, should be able to knock the big ruffian down, but they were well pleased, for they did not like Boggs, who was quarrelsome when drinking.

Presently, Boggs rose to a sitting posture and glared wildly around him. Then his eyes alighted upon Higgins and he remembered what had happened. A growl of rage escaped him, and he scrambled to his feet, leaped to where his belt lay on his coat, jerked the revolver out of the holster and was just on the point of leveling it, when his wrist was seized from behind, and a voice said in his ear:

"Hold on, Boggs. None of that. Hand over your gun and surrender. I arrest you, in the name of the law, for rustling cattle."

It was the Sheriff of the county, and Boggs wilted. He handed over the revolver without a word of protest, while the Sheriff snapped a pair of handcuffs on his wrists and started to lead him to his buggy. He had driven up unobserved just as Higgins knocked Boggs down.

"Hold on," said Higgins, addressing the Sheriff. "Your prisoner claims pay for some steers that a train killed. I'm the claim agent. To whom shall I pay the money?"

"Keep it yourself, for thrashing him," was the reply. "And, anyhow, he stole the steers, so is not entitled to the money."

"All right, Sheriff, and thank you," said Higgins.

The Sheriff assisted his prisoner into the buggy, got in after him and drove away; Higgins donned his coat and went to the hotel, while the spectators dispersed, discussing excitedly the thrashing Boggs had received at the hands of the claim agent.

Higgins returned to Cheyenne and reported to the superintendent, who was well satisfied with the manner of settlement.

"You are a good man for the work, Higgins," he said. "You handled the case very well indeed."

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THE MOODS of GENEVIEVE

No. 10.—THE REMINISCENT MOOD.

EVERY fiber of my being silently rejoices when the reminiscent mood steals with velvet tread into my tiny room, on a waning Sunday afternoon. The twilight softens into dusk, the last shaft of sunlight creeps into the corner and hides, the reminiscent mood gathers me in her melting embrace. "Relax, yield to me," she purrs.

Every nerve of me pulsates with ecstasy as I become her willing captive. All that is relentless and cold in this world of struggle is dashed into oblivion, as if by magic.

Trooping forth from the cobwebby cells of memory, vividly alive, clamoring for supremacy, come the intangible reveries of other days. Sorrowful ones, softened by the healing touch of time, romantic ones that have lost their spontaneous power, but not their charm. All these and more cry out in me, for a rehearsal before the audience of the present.

"Oh, reminiscent mood, you are all-powerful," I rhapsodize, "and for once I will give myself to you." I drag out a trunk from the corner and remove its cretonne covering. I lift the lid of this treasure chest, the only tangible link which connects me with the life that is past and this one. In another moment I am elbow deep in relics of other days, like James Whitcomb Riley's character was knee-deep in June.

Letters! The living contradictions of past sincerity. It is not with derision, or even cynicism, the reminiscent mood smiles. In all tenderness, I lay them back in the trunk-tary tomb, and with trembling fingers I reach for a box that reveals college pennants, dance orders, dinner favors, dried flowers and football scores.

A doll with eyes that stare at me in glassy coldness, and hair that resembles the bargain counter variety of today is the next object of my tender regard.

"Don't feel depressed," comes the comforting whisper of the dear reminiscent mood in the gathering gloom. "Depressed?" I cry. "Never! I am glad they are memories, and that I am living in the pulsating present. With all my heart I love them, but I do not wish them back again. I want to achieve, I want to accomplish, I want to be a living part of the great scheme of big things. What care I for butterfly cotillions, ball games and schoolgirl letters; I had them all in their natural order, but now I want the real, the satisfying achievement of a granite purpose."

Unnoticed and forlorn tumbles a little photo from the over-heaped pile of girlish treasures. I snatch it up and hold it to the last feeble ray of light. The pensive eyes of a frail girl being gaze back at me with sweet childish wistfulness.

With choking gulps I continue to gaze in the little face, until I have full mastery over the clamoring tears that threaten to escape. "Oh little girl self of the past, how I admire your timidity, your childlike trust. Have faith in me; I will not disappoint you. Forever more you shall dwell near me on my dresser, and you shall see; yes you shall see and sympathize with the fight I am making. You in your innocence cannot realize the cruel tests and dangers that beset me, the bitter disappointments and the defeated dreams. But I shall conquer, and you must believe in me."