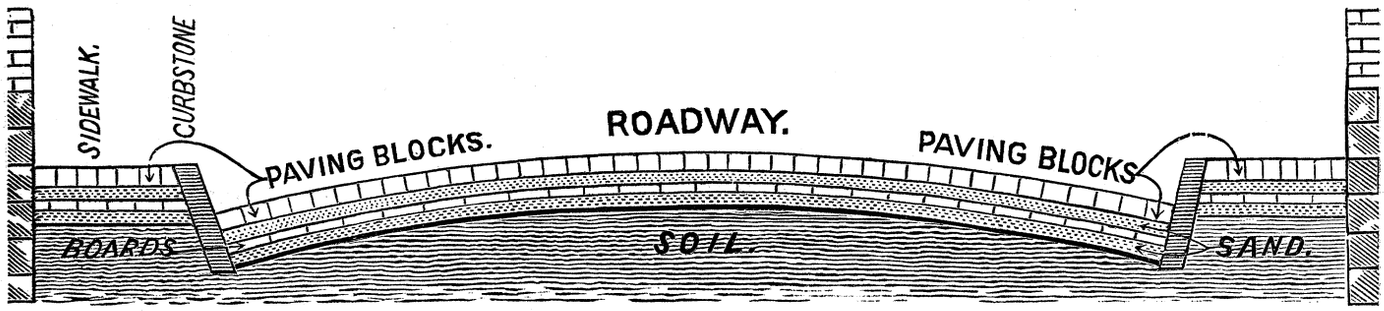
shape, the ground is covered with a layer of loose sand a few inches in thickness, to form a more perfect bed for the boards to rest upon, and to keep the boards from contact with the earth beneath, so as to form a sub-drainage against the effects of freezing weather. The sand is struck off to a perfect surface by a templet made to suit the desired curve, and guided by slats set to grade stakes.

The boards to be used need not be more than one inch in thickness, and ought not to be less than ten inches in width. The best timber for the purpose is that least subject to rot under the circumstances. Good white oak has been used successfully. The boards should be dipped in hot coal-tar or other preserving material. They are then carefully laid upon the sand-bed — lengthwise with the street would be the most convenient way — from curb to curb, with a regular curve all the way. No gutters are necessary, except such as are formed by the crown of the pavement. The broad surfaces of the boards bridge over all minor irregularities of the grading, and widely distribute all weights or pressure; and the floor forms a complete and perfect foundation for the hard material to follow. It is best to cover the boards with a layer of loose sand an inch or two in thickness, to form a more perfect bed for the bricks, which can be struck off with the templet, as before described.

The hard-burned bricks are next laid down. If they are of the ordinary shape of building-bricks in common use, they should be placed on edge, and laid "herring-bone" style, by



THE HALE PAVING SYSTEM.

which means all joints in the board floor are straddled. The seams are then filled with sand, and the bricks settled in their beds with a flatter, well rammed, or rolled with a heavy roller.

In cities having very heavy traffic to follow immediately the laying of the pavement, it is sometimes preferred, after the interstices between the bricks are half filled with fine sand, to complete the filling with hot pitch made by boiling gas-tar until the more volatile portions are driven off. This, when it cools, makes the pavement at once impervious to water, cements the bricks together, and helps to hold them firmly in place. This is generally advisable wherever clean fine sand cannot be obtained to fill the interstices.

A perceptible elasticity tends to favor the bricks when subjected to a crushing weight. The bricks being in place, their flat surfaces agreeing with each other and with the flat surface of the boards beneath, the bearings are perfect and equal: they can be broken only with difficulty, and cannot get out of place; and if at any time it is desired to lay pipes or sewers beneath the pavement, the materials, being all disconnected, can be rapidly taken up and laid aside, and as rapidly replaced at small expense, no new materials being required, and no patching to be done, every thing fitting in its place.

The durability of this pavement has been tested by several years of hard service in the streets of Charleston, W. Va., and in other places. The cost of this pavement in any given locality depends upon the cost of sand, oak or other durable boards, hard-burned brick, gas-tar, and labor at such locality; but it is claimed that it can be laid in any city or town in the United States, having length of streets sufficient to warrant the undertaking, for very much less than asphalt or Belgian granite blocks, and in most places for less than well-laid wooden blocks, or even good macadam roadways. It is controlled by the Hale Pavement Company of Staunton, Va.

MAJOR POWELL'S ADDRESS TO THE MINING ENGINEERS.[1]

MR. PRESIDENT, AND MEMBERS OF THE INSTITUTE OF MINING ENGINEERS, — It is with great pleasure that I greet you, and welcome you to Washington. The people of the United States obtain vast values from the rocks. The sum of the annual products of the mines of the United States is now more than six hundred millions of dollars. Over this production you preside. It is by your genius and skill that these industries are prosecuted. These affairs, which are confided to your guidance are not only great in themselves, but they constitute an integral part of all of the industries of the land, as they are all profoundly interdependent. The industries of manufacture, transportation, agriculture, and exchange have their interests, their prosperity, and their value to the people at large, all interwoven with the industry of mining, for the success and prosperity of which you are responsible.

Deep in the mountains lie the values which you seek; buried under the hills are the substances which you bring to light; concealed beneath the valleys are the materials which you resurrect. By your insight they are discovered. The prosperity of the land depends upon your knowledge of the structure of the earth and the secrets which lie buried in the depths of the rocks. By your knowledge and mastery over the powers of nature, all these substances are wrested from the adamantine grasp of mountain, hill, and valley, and placed in the possession of mankind. By your knowledge of the constitution of the rocks, and the various processes by which they may be transformed, these substances, so useful to mankind in the industries of civilization, are extracted, and transmuted into forms ready for the use of the people. But for your agency, the factory-wheels of the land would stop, the life of transportation would expire, the valleys of agriculture would be reforested, and the marts of exchange, now trodden by busy feet, would be clothed by a mantle of desolation.

That labor may be successful, that the ever-increasing wants of ever-increasing men may be supplied, labor must have guidance. In the centuries that have passed, tyrants have directed laborers as slaves, or held them under control as abject servants of want; but under modern culture the laborer is emancipated from slavery supported by chains and whip, and the slavery supported by want and dependence. Muscles of brawn are no longer shackled; but by your transcendent genius the powers that gleam from the sun upon the world, the powers that flow in great rivers, the powers that are concealed in banks of coal, filling the hills and mountains, the powers that lurk in the chemical re-actions of the rocks that constitute the crust of the earth, — all these powers are enslaved, all these powers are shackled, all these powers are made the servants of mankind. The crack of the lash is superseded by the glint of thought. The modern rulers are the men who control the powers of nature.

It is thus that the members of the American Institute of Mining Engineers constitute the greatest body of rulers now on the globe. When we consider the power that is wielded as a boon to mankind, there is no other parliament or congress whose delib-

[1] Delivered in Washington, D.C., Feb. 19.

erations and administrations so profoundly affect the welfare of mankind; and yet this body is held together as an organization of free men, each independent in his own sphere, governed only by a body of science, which is the common property of all, and the aggregated progress of research, invention, and exploitation. The efficient constitution and by-laws of this society are the formulated principles of science. For the organization of the labors of the past, the whip for the back has been the proper emblem of sovereignty. For the organization of the labor over which you preside, the hammer for the rock is the emblem of rule. You want in your deliberations no eagle on your mace, no unicorn and lion; but the balance and crucible properly symbolize to the world the power of your knowledge to control the industries of mankind.

Gentlemen, the industries which you control have their location in the foundations of the world. The valleys through which the living rivers roll, the prairies that spread their blossoms of beauty to the sun, the hills that billow with ripples of perpetual joy, the mountains where kissing clouds are transformed into cascades decked with rainbows, — all forms of land have their foundations laid in interlocked, crystalline gems, firmly set in a cement so delicately formed that the highest powers of the microscope fail to reveal its structure. The vast diastrophic powers of nature are forever engaged in mountain-building, against which the clouds hurl their storms to carve the hills and form the valleys; and, as the mountains appear above the level of the sea, the clouds bear them away on river-floods to build the fringing islands that are bathed by the tides. As these processes go on from geologic age to geologic age, the gold and the silver, the copper and the lead, the iron and the coal, and all the various substances with which you deal, are gathered in lodes, and segregated in bodies, and spread in strata, and are thus by nature separated from the great crystalline foundations of the world, and accumulated in masses. Then bounteous Nature repents of her generosity. Seeing what a store of wealth she thus brings together, she conceals it from the eye of the vulgar, and deems these treasures too precious to be intrusted to the ignorant. So she hides them away in fissures and in caves, she buries them under volcanic floods, she covers them with strata spread out by the waves of the sea; and she spreads over all a mantle of *dèbris* —of bowlders and gravels, and sands and soils; and over all she paints the bloom of the meadow, the variegated pattern of the copse, and the green of the forest; and then she smilingly exclaims, "My treasures are for those who can discover them. They who are worthy, by their intelligence may find; they who are unworthy, by their ignorance must remain destitute."

The people of the United States have chosen you — not by blind natural selection, but by intelligent choice—as their representatives; not to make laws, but to discover laws, — the laws of nature, by which all these concealed treasures may be brought to light, and fall into the possession of mankind. How well you administer the trust the six hundred millions of annual mining product in the United States attests.

I thank you, gentlemen, for this evidence of your labor and genius, and I congratulate your constituents for the choice they have made.

There is an organization with which I am connected, — the Geological Survey, — established by the general government, and endowed by the munificence of the people, that is working in cooperation with many other organizations established by the several States, the purpose of which is to aid you in your work. This organization is endeavoring to map the entire area of the United States for your purposes. It is endeavoring to trace the various geologic formations, and to discover their relations of sequence and interdependence. It is investigating the more recondite laws which control the distribution of values in the crust of the earth. All these things it is doing to aid you in developing the mining industries of America. Let me assure you, as a representative from this body, that we are informed with the same purposes as yourselves, and that we also believe that research is a boon to mankind, in part through the increase and diffusion of knowledge, but in larger part through the increase and diffusion of industrial blessings.

The history of the mining engineering of America is replete with the triumphs of science. In the Far West, where the soft breezes of the Pacific make music on giant Sequoian harps, there they harness rivers to monitors, and plough the mountains for gold; and the mining engineers, turning from these mighty tasks, engage in the deft and delicate work of extracting the grains of gold from the mountains of sand. Elsewhere they penetrate through shafts into subterranean depths, and employ, in gold and silver mining, machinery for power and efficiency elsewhere unparalleled. From the depths of the mountain they pump rivers thousands of feet to the surface, and they shoot cars of ore from the hell of darkness below, to the heaven of light above, as if they were playing with toy-guns, such Titan boys are they. Farther to the east, all over the land, the mining engineers are opening the great coal-fields, and gathering the sunshine which nature has been storing for unnumbered centuries in the depths of the earth. In the lost years the vegetation of America raised its verdant arms to heaven, and, grasping the glad sunlight, fell prostrate on the ground, and, still clinging to its boon of light and heat and power, was buried in great coal-formations beneath the accumulating sands of seas. This fossil power and heat and light are brought once more to the open day, and employed as powers for the machinery of America in warming the homes where wives and children dwell, and in illuminating the towns and cities of the land. These mining engineers have discovered that ofttimes the strata of the earth are domed by geologic upheavals, and that they thus constitute great natural receivers for the gases distilled in the depths below. Into these receivers they penetrate with their tubes; and, behold! light, heat, and power are given to the world. Time would fail to tell of all the triumphs of the mining engineers of America.

Gentlemen, I welcome you to Washington, and hope that your deliberations may be wise, and that your joy in our midst may be complete.

ELECTRIC WELDING.

IN accordance with instructions from the City of London Contract Corporation, Limited, Alexander B. W. Kennedy, F.R.S., vice-president of the English Institute of Mechanical Engineers, recently visited the United States in order to see what progress has been made in the direction of the practical carrying-out of the Thomson electric welding process. His report is dated Feb. 1. He visited the offices at Boston, and also spent about a week at their works at Lynn, Mass. He also visited five different works in the Eastern States (at Hartford, Ansonia, Brooklyn, and Trenton) where Thomson electric welders have been in use for some time (in some cases over a year) commercially.

The welding of iron and steel wire was one of the first matters successfully carried out by the company. He saw at the works of Messrs. Roebling, Sons, & Co., at Trenton, a welder which had been at work there for about thirteen months, for a great part of the time twenty hours per day, and the counter of which showed that 193,890 welds had been made with it. He also examined another wire welding machine at the Trenton Iron Works (Messrs. Cooper, Hewitt, & Co.), which had done about nine months' work, and had made 22,095 welds, and at the same works a portable machine, recently installed, which had made 9,022 welds. This last machine was so arranged that it could be carried about easily by two men, and connected with the mains at any part of the immense shop in which it was placed, so as to be used for mending or other welding, wherever required, without the necessity of bringing a heavy coil of wire to it. The managing partners of both the works spoke in the highest terms of the efficiency of the machines, and as to the great saving caused by their perfect utilization of short lengths and broken wires. The welding of brass and copper wire, especially the latter, naturally presented much greater difficulties than that of iron wire, but those seem now to have been overcome. Mr. Kennedy saw at the works of Messrs. Wallace & Sons, in Ansonia, a welder for this purpose, which was one of the first machines put down, and had made 30,415 welds (by register) during the last thirteen months in copper and brass wire; the latter, in