and magnetism, the first regular series on natural philosophy which had been prosecuted in this country since the days of Franklin. These researches gave him a wide reputation, and led to his call in 1832 to the chair of Natural Philosophy in the College of New Jersey, at Princeton. In 1846, at the organization of the Smithsonian Institution at Washington, Professor Henry was appointed its Secretary, which post he since constantly held. He was also one of the members of the Lighthouse Board of the United States, president of the National Academy of Sciences, besides a member of a large number of foreign learned societies.

It would require a volume to explain all of Professor Henry's investigations and discoveries in detail. The following, however, is a brief enumeration of the more important ones: First, a sketch of the topography of the State of New York; second, in connection with Dr. Beck and Simeon De Witt, the organization of the meteorological system of the State of New York; third, the development for the first time of magnetic power sufficient to sustain tons in weight in soft iron by a comparatively feeble galvanic current; fourth, the first application of electro-magnetism as a power to produce continued motion in a machine; fifth, an exposition of the method by which electro-magnetism might be employed in transmitting power to a distance, and the demonstration of the practicability of an electro-magnetic telegraph, which, without these discoveries, was impossible; sixth, the discovery of the induction of an electrical current in a long wire upon itself, or the means of increasing the intensity of a current by the use of a spiral conductor; seventh, the method of inducing a current of quantity from one of intensity, and *vice versa;* eighth, the discovery of currents of induction of different orders, and of the neutralization of the induction by the interposition of plates of metal; ninth, the discovery that the discharge of a Leyden jar consists of a series of oscillations backwards and forwards until equilibrium is restored; tenth, the induction of a current of electricity from lightning at a great distance, and proof that the discharge from a thunder-cloud also consists of a series of oscillations; eleventh, the oscillating condition of a lightning rod while transmitting a discharge of electricity from the clouds, causing it, though in perfect connection with the earth, to emit sparks of sufficient intensity to ignite combustible substances; twelfth, investigations on molecular attraction, as exhibited in liquids and in yielding and rigid solids, and an exposition on the theory of soap bubbles. These originated from his being called upon to investigate the causes of the bursting of the great gun on the United States steamer Princeton. Thirteenth, original experiments on and exposition of the principles of acoustics, as applied to churches and other public buildings; fourteenth, experiments on various instruments to be used as fog signals; fifteenth, a series of experiments on various illuminating materials for lighthouse use, and the introduction of lard oil for lighting the coasts of the United States; sixteenth, experiments on heat, in which the radiation from clouds and animals in distant fields was indicated by the thermo-electrical apparatus applied to a reflecting telescope; seventeenth, observations on the comparative temperature of the sun spots, and also of different portions of the sun's disk; eighteenth, proof that the radiant heat from a feebly luminous flame is also feeble, and that the increase of radiant light by the introduction of a solid substance into the flame of the compound blow-pipe is accompanied with an equivalent radiation of heat, and also that the increase of light and radiant heat in a flame of hydrogen, by the introduction of a solid substance, is attended with a diminution in the heating power of the flame itself; nineteenth, the reflection of heat from concave mirrors of ice and its application to the source of the heat derived from the moon; twentieth, observations in connection with Professor Alexander on the red flames on the border of the sun, as observed in the annular eclipse of 1838; twenty-first, experiments on the phosphorogenic ray of the sun, from which it is shown that this emanation is polarizable and refrangible, according to the same laws which govern light; twenty-second, on the penetration of the more fusible metals into those less readily melted while in a solid state.

In relation to the electro-magnetic telegraph, it has been clearly shown that Professor Henry was the originator of the only practicable method of sending telegraphic signals through long distances, and that he was the first to put into actual operation a telegraph of this kind. The inventions of Henry are all embodied in the Morse instrument, and if the former were to-day discarded it would be impossible, in a commercial sense, to send telegraph messages. Morse's instruments, on the other hand, might be withdrawn from use without serious difficulty. Indeed, the instrument upon which Morse most strenuously based his claims as originator of the telegraph, namely, the recording stylus, which produced a signal on paper, has already gone almost entirely out of use, and Henry's system of reading by sound is preferably employed. The honor of originating the telegraph undoubtedly belonged to Professor Henry, and had Congress, as it well might have done, granted him a patent for his inventions, although he never applied for this protection, at the time of his death he would have enjoyed a monopoly, as patentee, of all the telegraphs, railway signals, fire alarms, and electro-magnetic machines of every kind now in the United States, for he was the father of them all. It is hardly necessary to point out how enormously wealthy this would have made him, but he preferred to take his reward in the knowledge of having benefitted humanity, and in the enduring renown which posterity will accord to him.

MEDDLERS IN ARTS IN WHICH THEY ARE NOT SKILLED.

In his enumeration of the mischievous effects of the patent law as it now stands, before the House Committee on Patents, Mr. Raymond dwelt at some length on "a useless and pernicious class of patents," which the system encourages; namely, patents issued to "ignorant and officious meddlers in arts in which they are not skilled."

As a very bad case of such meddling Mr. Raymond pictured a backwoods Irishman, who, while taking his biennial trip along the railroad track to town, sees that some of the nuts attaching the fish plates of the rail are loose, and remembering that "the squire" made a great deal of money out of a patent, proceeds to invent a nut lock. We are to infer that a proper patent system would put a summary stop to this sort of foolishness. Here are some hundreds of skilled railway engineers and constructors, presumably competent to supply all the needs of a well regulated railway, and an unskilled Irish laborer steps in to instruct them in their art! Worse yet, he takes out a patent for his invention, so that if they should want to use his invention they must pay him a royalty therefor! Could anything be more atrocious, more oppressive to the high and mighty railway interest? And the influence of the patent law is to set every other man in the land studying over some device by which he can meddle in some art or other, regardless whether he is skilled in it or not. No wonder the advocate's mind revolts at it!

The mischief done by such meddlers is incalculable. Only the other day there was an art that had reached a marvelous stage of development. Some of the cleverest men of the century had been engaged upon it; and with a most scientific adjustment of reeds, organ pipes, bellows, diaphragms, and what not, they had succeeded in making a machine that could speak a number of words very distinctly. Then along comes a fellow, utterly unskilled in physiology, acoustics, organ making, and all that sort of thing, who takes a simple plate of sheet iron and makes it talk like a Christian. At one stroke a promising art is dashed to the ground, never to be revived. What chance had the most learned talking machine maker in competition with an unskilled meddler who could make a tin box cover imitate any sound that human ingenuity could bring before it?

There is another fellow, a teacher of deaf mutes, who has lately been meddling in an art in which he was not skilled. Already his uncalled for interference has had an enormous effect upon one of the most useful and flourishing enterprises of the age. He was not a telegrapher, not even an electrician; yet he has presumed to invade the domains of both those useful classes of the community. And the patent law encourages him! Curiously the first, though less successful, telephone maker was likewise a teacher, utterly unskilled in telegraphy and its kindred sciences. In this connection we might mention also that meddlesome portrait painter, Morse, who made such a revolution in the business of conveying intelligence, a generation or so ago.

Indeed it would seem that nine out of ten of the men who have contributed most to the progress of invention have been meddlers in arts in which they were not skilled. There was that early schoolmaster by the name of Whitney, who invented the cotton gin and revolutionized the agriculture of the South and the cotton manufactures of the North. He never raised a cotton plant in his life, nor did he ever weave an inch of cotton. Even more serious have been the effects of the agricultural meddlesomeness of another taker out of patents, McCormick by name, the inventor of the reaper. His interferences in arts in which he was not skilled, under the encouragement of our patent system, fairly mark an era in the history of his country. Under a patent system of Mr. Raymond's revising such things would not be allowed to happen.

Fulton was another meddler. In his day the business of transportation had become enormous for a new country, and the broad canvas of our shipping whitened every sea. What did he know about ship building? He never built so much as a canal boat. Yet he presumed to introduce a new order of naval architecture, a new method of propulsion, a new era in commerce. Not less unwarrantably meddlesome was Stephenson when he set his iron horse in motion. For many more than the hypothetical "coo" did the new engine threaten to be "verra bad;" and the Raymonds of the day had no lack of clients who deemed it an outrage that this man should be permitted to interfere in arts in which he was not skilled to the destruction of long established and prosperous industries. He had never owned or driven a passenger coach; nor had he any experience in the management of a wagon train.

A still earlier fruit of the English patent system was the steam engine of James Watt, whose influence has been felt in every art known to civilized man—in arts in which he was not merely unskilled, but which without him might never have been called into existence. Bessemer was another meddler—a bronze worker, who never made a pound of steel in his life until after he invented the process which revolutionized that important department of manufacture, making it possible to produce four tons of steel at what had been the cost of one.

We venture to say that Howe never so much as sewed on his own trowsers buttons before he began to make the first sewing machine; and everybody knows the results of his meddling.

So we might go on enumerating to the end of the chapter. The inventors of improvements in the means, methods, and appliances in general use are most commonly men skilled in the arts which they improve; not so the inventors of radically new means and processes. These as a rule are outsiders—meddlers, Mr. Raymond calls them; and a patent system which should bar them from patenting their inventions because they are not skilled in the arts which they seek to supersede or radically improve would shut off the most useful and productive outflow of inventive genius. It is true that these men are apt to be at the outset as poor as Mr. Raymond's Irishman. It is true, too, that the hope of making money is the chief inducement which leads them to patent their inventions. True also that such inventions often subject great interests to temporary inconvenience, and put a stop to profits arising from the use previously of satisfactory devices. Nevertheless the world gains enormously by them; and a people as intelligent as ours will not consciously favor any measure likely to debar or discourage the makers of such inventions, meddlers though they be in "arts," in which they are not skilled.

CLEARANCE AND COMPRESSION.

People used to understand by "clearance" only the distance between the piston and the cylinder head when the former stands at stroke end, it being necessary to allow a little such "clearance" at each end of the stroke to prevent possible accident in case the connecting rod brasses wore and let the piston make a slight overstroke. Later, when it came to be understood that "clearance" caused a difference in the working of the engine, the term began to be applied to the volume and not to the length of the space, and to include in addition the volume of the admission ports; so that now "clearance" in calculation means the whole volume between the piston at stroke end and the slide valve. The area of the space back of the piston is not cylindrical, nor that of the admission channel regular; but both may be measured by filling them up with shot or with water.

In calculating it is more convenient to express clearance in fractions of the piston displacement than in actual measures; thus it will run from, say, 0·02 up to 0·1, generally being least in large engines and in those having poppet or Corliss valves.

It is found convenient to prevent the exhaust steam escaping from the cylinder during the whole return stroke; but as the exhaust port is closed before the stroke end, there is steam on both sides of the advancing piston, which compresses the exhaust steam imprisoned until the clearance space contains steam sometimes of higher pressure than that in the boiler.

If there be no practical compression, the clearance space is, at the end of the return stroke, full of low pressure steam (of not more than 2 or 3 pounds per square inch), and the boiler steam rushes in and works on the piston about as though this exhaust steam were not present. But owing to the clearance the new steam does not do as much work as though the piston moved through the whole space. Often the cylinder steam is drier where there is clearance. But neglecting this and considering an expansive engine: If the clearance be $\frac{1}{10}$ and the cut off $\frac{1}{8}$, the rate of expansion will be

$$\frac{1\frac{1}{10}}{\frac{1}{10}+\frac{1}{8}} = 4\tfrac{8}{9}, \text{ instead of } \frac{1}{\frac{1}{8}} = 8.$$

Compression has very little influence on the rate of expansion, nor on the work done, but a good deal on the back pressure and on the steam consumption, and somewhat on the state of the steam. Thus, when the steam enters the partly empty clearance space it often gets drier, but where there is compression the amount of drying is less, especially when the clearance is full.

The cushion steam is first compressed by the piston until the stroke end (or near it if there be lead), at which the clearance spaces are filled with steam at the "cushion pressure;" then, if this cushion pressure is below that of the boiler, as is usual, the cushion steam is further compressed by the entrance of the fresh working steam from the boiler; thirdly, it enters the working space of the cylinder, and is generally cut off; it then continues to expand while doing work upon the piston; and fourthly, it suddenly expands, doing no work, except overcoming back pressure.

The working steam goes through all its changes nearly as though there was no clearance. The cushion steam goes through a series of changes without condensation.

Comparing two cylinders having the same total volume, but in one of which the piston stroke is shortened so as to give, say, $\frac{1}{10}$ clearance, and in which there is also compression, the ratio of expansion is the same; the mean forward pressure is independent of the compression, but is lessened by the clearance; the steam consumption is diminished $\frac{1}{10}$; the back pressure increased; the work done on the piston per pound of steam increased $\frac{1}{10}$; the useful work increased in a more complicated ratio, according to the amount of cushion; compression diminishing steam consumption, but also lessening the whole useful work done.

Calculation and experiment will adjust the amount of compression so as to reconcile small steam consumption and great useful work done.

It may generally be stated that there is always a loss by clearance, but that judicious compression reduces it to a minimum.

RICE GLUE.—The fine Japanese cement is made by mixing rice flour with a sufficient quantity of cold water, then boiling gently, with constant stirring.