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## THE IRON AND STEEL INSTITUTE.

THE Iron and Steel Institute, although a very vigorous and influential, is still a comparatively juvenescent body. It was founded in 1869, "to afford a means of communication between members of the iron and steel trades upon matters bearing upon their respective manufactures," and this is done by holding periodical meetings for the purpose of discussing practical and scientific subjects having reference to these great industries. The first president of the Institute was the Duke of Devonshire, who was followed by Sir Henry Bessemer, F.R.S., the founder of the ingenious process and the important industry that bears his name. Since then the presidential chair has been occupied at two yearly intervals by the leading scientists and manufacturers in the trade.

The affairs of the Institute are controlled by a council of thirty members, selected from all the chief

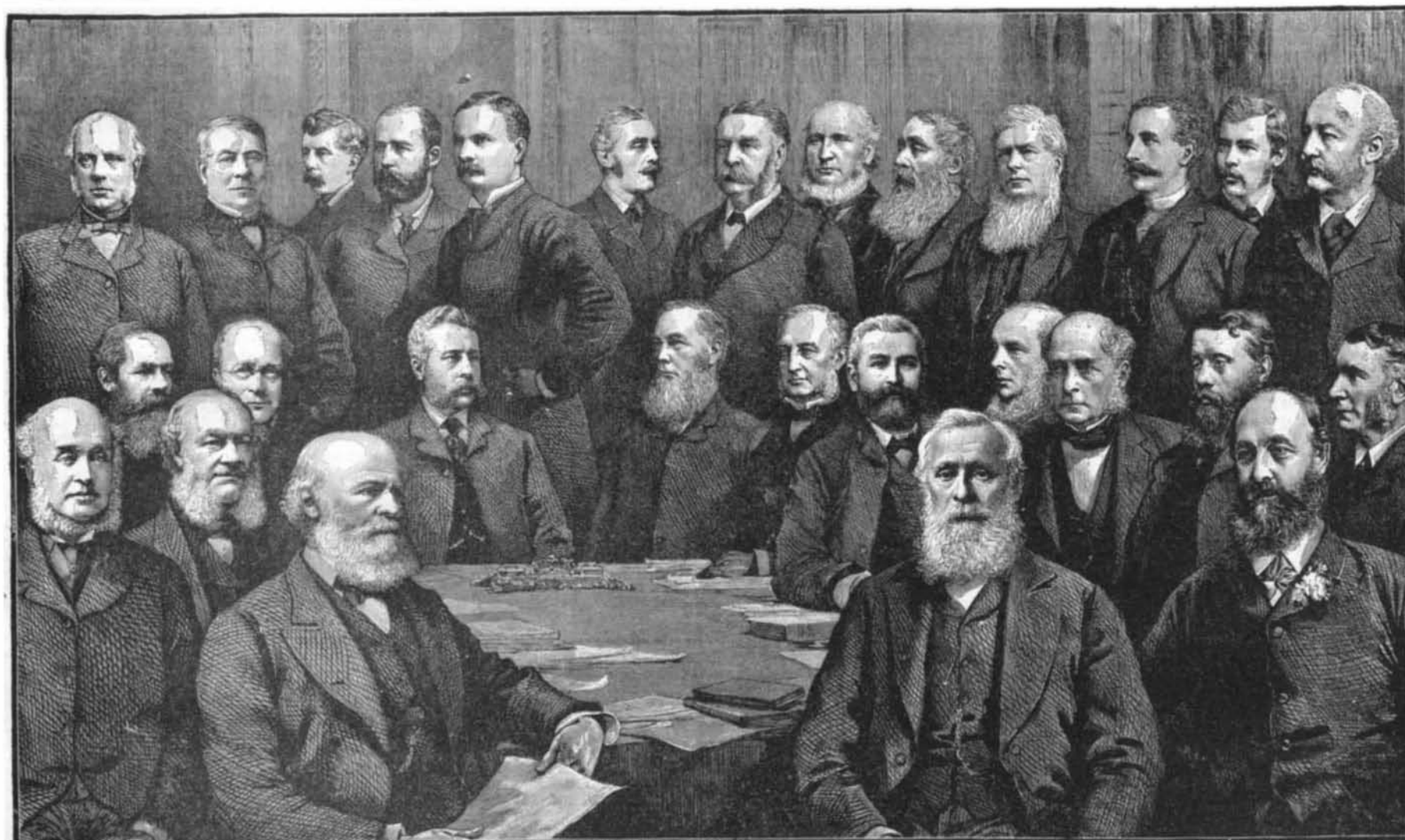
developments in which the Institute has borne a leading part.

The iron and steel industries embrace three leading departments or branches—pig iron, manufactured iron, and steel. Great improvements have been made in the first and the third of these, and their production has enormously increased. Manufactured iron, on the contrary, has been almost stationary as regards its processes of manufacture, while its use has been so far superseded by that of steel that its ultimate extinction is regarded as only a question of time. The principal changes that have occurred in the pig iron manufacture have been the increase of the height and capacity of the blast furnace, the use of higher pressures of blast, the utilization of the waste gases of the furnace for raising heat and steam, and otherwise, the introduction of more perfect types of stoves, engines, etc. These and other recent developments have enabled the maximum production of furnaces to be raised from 400

close on 6,000,000 of tons. In the mean time Bessemer steel has been employed for a very great variety of purposes to which wrought iron was formerly put, and the extent of the economy thereby effected—as a consequence of the greater durability of steel—has been calculated at many millions.

Scarcely less important has been the new departure initiated by the late Sir William Siemens, a past-president of the Institute, whose now well known process for the manufacture of steel on the open hearth was then in embryo, whereas nearly a million and a half of tons are now annually produced, about one-half of which is turned out in the United Kingdom. It is impossible to trace here the various steps whereby this movement has been accomplished; nor can we give adequate expression to the enormous benefits that it has conferred upon the general public, alike as investors, as consumers, as railway travelers, as ship owners and ocean voyagers, and in a thousand other ways.

Mr. W. Richardson. Mr. W. H. Bleekly. Mr. John Cunningham. Sir James Kitson. Mr. W. Jenkins. Mr. Henry Robertson. Mr. W. T. Crawshaw. Mr. E. Windsor Richards.  
Mr. G. J. Barker. Mr. E. P. Martin. Mr. David Dale. Mr. W. Evans. Mr. Percy C. Gilchrist.



Sir J. G. N. Alleyne, Bart. Mr. E. Fisher Smith. Sir J. W. Pease, Bart., M.P. Mr. Daniel Adamson. Mr. Robert Heath. Mr. Charles Markham. Sir H. Bessemer. Lord Edward Cavendish, M.P.  
Sir John Ramsden. Mr. T. E. Horton. Sir Lowthian Bell, Bart. Mr. J. Riley. Sir Bernhard Samuelson, Bart., M.P. Mr. G. J. Snelus. Mr. W. Whitwell.

## OFFICERS AND COUNCIL OF THE IRON AND STEEL INSTITUTE.

iron making districts in the United Kingdom, with some regard to the due and proportionate representation of each. The existing president is Mr. Daniel Adamson, the president, until he retired quite recently, of the Manchester Ship Canal Company. The secretarial office was filled for the first eight years of the life of the Institute by the late Mr. John Jones, and has been held for the last ten by Mr. J. S. Jeans, who is the author of several well known scientific and economic works. Since its establishment the Institute has held meetings at almost every important center of the iron and steel industries, both at home and abroad. Four meetings have been held on the Continent—where the Institute has many members: the first at Liege, the second at Paris, the third at Dusseldorf, and the fourth at Vienna. The Institute is holding its autumn meeting this year at Manchester, during the four days commencing September 14. The present membership of the Institute is about 1,400, and the last report of the council bore witness to the fact that, notwithstanding the extraordinary depression of the iron and steel industries within recent years, the membership steadily increases.

In the history of both national and international industry there have been few phenomena more remarkable than the progress and transformations that have marked the course of the industries which the Iron and Steel Institute represents. A few of the leading landmarks of this progress may be briefly indicated by way of illustrating the singularly important de-

velopment in which the Institute has borne a leading part. The iron and steel industries embrace three leading departments or branches—pig iron, manufactured iron, and steel. Great improvements have been made in the first and the third of these, and their production has enormously increased. Manufactured iron, on the contrary, has been almost stationary as regards its processes of manufacture, while its use has been so far superseded by that of steel that its ultimate extinction is regarded as only a question of time. The principal changes that have occurred in the pig iron manufacture have been the increase of the height and capacity of the blast furnace, the use of higher pressures of blast, the utilization of the waste gases of the furnace for raising heat and steam, and otherwise, the introduction of more perfect types of stoves, engines, etc. These and other recent developments have enabled the maximum production of furnaces to be raised from 400

or 500 tons to upward of 1,600 tons per week, and this has been concurrent with an enormous economy of production as regards fuel and labor. In 1869, Great Britain imported hardly any ores for the iron manufacture. In 1882, we imported more than three and a half millions of tons, chiefly from Spain, and 15 per cent. of all the iron made in this country is now smelted from imported ores. It is, however, in the United States that the most remarkable developments have occurred. In 1869, that country only produced about one and three quarter million tons of pig iron. In 1886, the production was close on six million tons. Germany has also gone ahead with remarkable vigor, producing about three and a half millions of pig in 1886, as compared with 1,180,000 tons in 1869.

We must, however, inquire into the annals of the steel manufacture if we are to ascertain the real value of the great work that has been accomplished since the Iron and Steel Institute was founded. In 1869 the requirements of the world for structural purposes of all kinds were met by manufactured or wrought iron—a material produced with a very heavy expenditure of human toil and a great consumption of fuel—which has a fibrous texture, and, having its strength in one direction only, is liable to laminate and give way unequally. Bessemer introduced his remarkable process for the manufacture of steel in 1856. In 1869 not more than 350,000 tons of Bessemer steel were made in the whole world, and only 160,000 tons in the United Kingdom. In 1886, however, the production of such steel was

The transformation that has been thus effected in the conditions of the manufacture and application of the useful metals is the best witness and the noblest monument to the useful career of the Institute, which the authors of that transformation have brought to its present highly prosperous and influential position.

Our portraits of the officers and council of the Iron and Steel Institute are from photographs.—*London Graphic*.

## THE TRANSMISSION OF NATURAL GAS LONG DISTANCES.\*

By GEO. H. CHRISTIAN.

THE question of the pipage of natural gas long distances by its own pressure is one of great importance at the present time. We can hardly read a scientific paper that this subject is not spoken of, and various opinions expressed, but it is only by constant discussion that we can obtain a complete understanding of the subject and fully appreciate the future possibilities in this direction.

The practical questions of leakage, dangers from explosions, and the controlling of gas under high pressures have been solved by those working in this field, and I will give the facts as determined from practical working in Pittsburg and Allegheny City. I quote

\* Read by request, February 2, 1887.

from results given to the public by the Philadelphia Co., Pittsburg.

"It being practically impossible to make a series of joints in the ordinary way that could be depended upon to remain gas tight, the attention of inventors and engineers was then directed to devising and perfecting suitable safety appliances, first to make the joints more secure, and second to confine within certain limits any escaping gas, and to conduct it through auxiliary pipes to places where it could escape safely. Such a system was perfected and applied to more than 100 miles of pipes in Pittsburg and Allegheny City, with most gratifying results. By its use the actual loss of gas by leakage is less than one per cent., and the danger of explosions from this source is, therefore, practically overcome. They have also devised the means of detecting and readily locating any leaks that may occur, without having to tear up the street to locate the same.

"Automatic pressure regulators have also been devised and patented, by which the pressure can be so accurately adjusted that the pressure of the gas as it enters the regulator through the inlet pipe may have a wide range of variation, but when it passes out of and beyond the regulator it will maintain a constant pressure of any degree required. Automatic shut-off valves and temperature regulators have also been devised." Mr. Bannister, in his book from which I have quoted above, closes as follows: "That the problems presented to the inventor and his coadjutors by the occurrence of natural gas have been completely solved must now be apparent to all. The pipe systems and appliances for insuring safety and preventing waste in its conveyance and distribution, and the devices for its perfect adaptation to every use as fuel, have been brought to such a high state of perfection that there is really nothing further to be desired."

It is left to us to but demonstrate the possibility of conveying this fluid in large quantities great distances by its own pressure, to induce capital to flow into this channel of trade. It is claimed by many that there is a limit in distance soon reached beyond which the cost of plant in proportion to quantity of gas delivered will render it impossible to give more than a few cities in this country the benefit of this fuel; and we see daily instances of the effect of this view in manufacturers moving their factories to places where natural gas is found in abundance. In an issue of *Van Nostrand's Magazine* can be found a scientific discussion on the flow of compressed air, and formula deduced almost identical to the water formula "for flow of water through pipes." This article is from the pen of Prof. Robinson, of the State University.

You will find his formula, derived from the principle of adiabatic expansion of gases, to exactly coincide with results obtained by a formula which I shall use, and which is derived from considering the work done by the expansion and friction of the gas. These facts, I believe, clearly prove the correctness of both. We will not go into the mathematics of this subject, but consider the forces acting when gas is flowing, and determine analytically the results.

Let us take a pipe of large diameter and great length, connected with a number of gas wells, allow this pipe to fill, and the terminal pressure to reach that at the wells. Now let us open a valve at delivery end, and ascertain the quantity discharged; which quantity will depend upon the following variables: the pressure of the wells and the length and diameter of your pipe line; the forces at work are expansion and friction, and it is the latter force we must determine.

From our knowledge of the flow of water through pipes, we have total head,  $H$ , in a line of pipe equals  $h + h'$ , where  $h$  is velocity head and  $h'$  friction head. Now these are the only losses on the supposition that the gas maintains constant temperature. We can then, having given the initial pressure, distance, and size of pipe, determine the friction loss and quantity discharged. In applying the formula for discharge you will find that the friction loss in uniform diameter pipe line increases in a rapid ratio as you approach the end of your line, and that to pipe gas with least outlay of plant, your pipe must be of variable diameter, and it remains to ascertain the degree of this increase. To do so, let us look at the equation of friction, which is written thus:

$$F = CH \frac{L}{D} S = F.$$

$C$  = constant.  
 $F$  = total friction.  
 $H$  = velocity head in pounds per square inch.  
 $L$  = length in feet.  
 $D$  = diameter in feet.  
 $S$  = coefficient of friction.

From this formula we see that the friction increases as the square of the velocity, inversely as the diameter of pipe, and directly as the length; also directly as the quotient of the pressure in pounds per square inch above vacuo divided by atmospheric pressure. Your pressure decreases as you advance from the wells, and your velocity increases. The density of your gas, however, decreases, so that your friction loss on this account will not increase as the square of the velocity, but more nearly as to the velocity. By increasing the diameter of your pipe to meet this increased velocity, and thereby maintaining a more constant velocity, you can keep your friction loss within small bounds.

To lay out a pipe line so that its friction losses shall remain within the pressure available, we have but to keep in mind this fact: that in steady motion the same weight of fluid must pass each cross section in a unit of time, whether your pipe is of uniform or variable diameter. Let us, then, take an example: Suppose we are required to determine the cheapest line of pipe possible to transport 225,000,000 cubic feet daily, and deliver the same at terminus of line 300 miles distant from the wells, having an available pressure at wells of 300 pounds per square inch. We will assume the initial diameter of pipe line to be 2 feet. A discharge of 225,000,000 cubic feet per day would be 2,600 cubic feet per second. The area of pipe 2 feet diameter is 3.1416 square feet. 2,600 divided by this area, 3.1416, equals 821. This divided by  $\frac{314.7}{14.7}$  equals 39 feet per second as velocity in first mile, and from the formula for friction for gas specific gravity 0.6, the loss in friction for the first mile will be 5.2 pounds. Now if we should con-

tinue our pipe 2 feet in diameter for 10 miles, we should have a velocity in the tenth mile of 47 feet per second, and a friction loss of 6.4 pounds, making a total loss for friction in the first 10 miles of pipe 58 pounds, and will leave you a pressure at the eleventh mile of 242 pounds. Here let us increase to 2½ feet diameter and continue this diameter for 30 miles. Your velocity and friction loss in the first mile will be 30½ feet per second velocity, and 2 pounds per mile friction loss, and in the last mile of 2½ foot pipe velocity 41 feet per second, friction loss 2.76 pounds per mile, making a total loss of 70 pounds in the 30 miles, and leaving a pressure of 172 pounds at the forty-first mile point; here we will increase to 3 feet diameter and continue same 20 miles. Your velocity in first mile will be 29.3 feet per second, and friction loss of 1.15 pounds per mile, and in last mile of 3 foot pipe, velocity 34 feet per second, friction loss 1.38 pounds per mile, making a total loss of 25 pounds in the 20 miles, and leaving a pressure of 147 pounds at the sixty-first mile point; here we will increase to 3½ feet diameter, and continue same for 15 miles. The velocity in first mile will be 25 feet per second, and friction loss 0.6 pound per mile, and in last mile velocity 27 feet per second, friction loss 0.68 pound per mile; total loss in 15 miles, 10 pounds, leaving a pressure of 137 pounds at the seventy-sixth mile point; here we will increase to 4 feet diameter and maintain same to terminus of your line, or for 235 miles, and your total loss in that distance will be 136.8 pounds, leaving 0.2 pound pressure to maintain the flow of gas there of 207 feet per second.

Our pipe line beginning 2 feet in diameter and ending 4 feet will transport 225,000,000 cubic feet every 24 hours with an initial pressure of 300 pounds per square inch. This line, I believe, you will find to be the cheapest that could be built to do that work, but for other considerations it would be better to lay a double line of pipe, for the more perfect protection of your consumers in case of accident to one line. Having calculated for a pipe of initial diameter of 2 feet, we can readily ascertain what initial diameter would be required using two pipes to convey the same amount of gas, and you would find that two lines beginning 18 inches diameter and ending 3 feet will deliver nearly the same amount as the 2-4 foot single line will do. I wish to show you a peculiarity of these friction losses. Let us take a pipe 4 feet diameter and continue this diameter the 300 miles, and assume a discharge same as before, 225,000,000 cubic feet daily, what initial pressure would be required?

Beginning at the terminus and working backward, we shall find the losses thus:

1st to 6th mile	.....	6 miles	.....	14½ lb.
6th " 18th "	.....	12 "	.....	17 "
18th " 36th "	.....	18 "	.....	17 "
36th " 60th "	.....	24 "	.....	17 "
60th " 90th "	.....	30 "	.....	17 "
90th " 126th "	.....	36 "	.....	17 "
126th " 168th "	.....	42 "	.....	17 "
168th " 216th "	.....	48 "	.....	17 "
216th " 270th "	.....	54 "	.....	17 "
270th " 300th "	.....	30 "	.....	8½ "
300 miles.				Friction loss... 159 lb.

The friction loss remaining the same for every additional increment of 6 miles, thus you would need but 160 pounds of well pressure to transport 225,000,000 cubic feet daily 300 miles through a pipe 4 feet diameter throughout. Again, you can readily obtain total friction loss in any pipe line of constant diameter, length and pressure given. Assume a discharge, calculate the friction loss in first mile, multiply this friction loss by the number of times in density the gas in first mile is above atmosphere, add to this the friction loss in last mile, and divide this sum by  $(\frac{P}{P_0} \times 1)$ .  $P_0$  equals initial pressure above vacuo.

$P$  equals 14.7 atmosphere pressure. Thus, for last example: Terminal velocity 207 feet per second, initial pressure 159 pounds.  $\frac{159+14.7}{14.7} = 11.6$ . The friction loss in first mile will be 0.3 pound. This multiplied by 11.6 equals 3.48 pounds. Friction loss in last mile 3.2 pounds; adding 3.48 + 3.2 equals 6.68.  $\frac{6.68}{11.6+1} = 0.53$

pound as average friction loss per mile, and for 300 miles  $0.53 \times 300$  equals 159 lb. as before. This renders quite simple what would otherwise be a tedious calculation. Let us now look into the cost of our pipe line.

The average pressure in the 10 miles of 2 foot pipe would be 275 pounds. But since there would be times when the whole pressure of 300 pounds would be on the whole length of 10 miles, it should be made sufficiently strong to safely withstand the same. The thickness of said pipe should be, if of wrought iron or steel plate, ¾ inch thickness, costing \$25,000 per mile complete. The 2½ foot pipe would also have to stand 300 pounds pressure, and would have to be 7/8 inch thickness, and cost \$37,000 per mile. Here an automatic governor should be placed in your pipe, so as not to allow a greater pressure beyond this point than 225 pounds per square inch; for if the pipe line was doing its full capacity, the pressure would be but 172 pounds, and less on the 3 foot pipe. With 225 pounds pressure, thickness of pipe would be ¾ inch and cost \$37,000 per mile. Your 3½ foot diameter would require to be 7/8 inch thickness, and cost \$45,000 per mile. Here, again, an automatic pressure regulator should be placed to prevent the pressure beyond exceeding 160 pounds maximum, and your 4 foot would average in thickness throughout its entire length ¾ inch, and cost \$30,000 per mile. This would make your pipe line net complete ten million dollars. Add to this the cost of right of way, gas property, drilling of wells, and city pipe system, and your total cost of plant would be nearly \$16,000,000.

In the above estimate, I have assumed the pipe to be of wrought iron boiler plate, double riveted, and to be laid above ground, and arrangements made for the contraction which must take place when the gas is turned on, either by using expansion joints or laying the pipe in a wavy line.

There is another material that could be used, which, I think, would be even cheaper than riveted work, and that is open hearth or Bessemer cast steel pipe. This metal can be made in large amounts possessing a ten-

sile strength of 60,000 lb. per square inch, and allowing a factor of safety of 10, you would have the same strength for each inch cross section as from a 3 inch cross section of cast iron, and the weight would thus be one-third lighter than cast iron, but heavier than boiler plate. These pipe ought to be made for 2¼ cents per pound, or even less for such large pipe. It is not my intention to go into the detail of cost, but simply to show that a pipe line can be laid to carry a large quantity of gas a great distance, and at a cost within bounds. At first sight, the sum of \$16,000,000 might seem to be so great as to preclude capitalists from investing in such a scheme, but when we estimate the receipts from sale of this gas, we will probably change our minds.

One thousand cubic feet of natural gas contain 1,000,000 heat units; one bushel or eighty pounds of hard coal, 1,200,000 heat units. In burning gas for domestic purposes you realize 50 per cent. more of its heat than from burning coal, or your gas would be equal to 100 pounds of hard coal. Hard coal in New York City or Philadelphia is worth \$5 per ton, or 25 cents per 100 pounds. If we should sell this gas for 12½ cents per 1,000 cubic feet, it would reduce the cost of fuel to the consumers 50 per cent. The daily receipts from sale of 200,000,000 would be \$25,000, or \$10,000,000 per year. Allowing fifteen per cent. on investment, you have remaining for yearly running expenses, improvements, repairs, and sinking fund, \$7,750,000.

You may ask, How is it that you figure such a large revenue, when in Pittsburg their total yearly revenue is but \$2,500,000? The facts are, in Pittsburg soft coal is used, and sells for \$1.25 per ton, as against \$5 in New York.

If you should pipe from Findlay Field to Chicago, you could not realize over 10 cents per 1,000 cubic feet, but even here \$8,000,000 per year revenues should pay handsomely.

Cleveland and Cincinnati are both nearer the gas territory, and the cost of plant very much less. These places must very soon avail themselves of this cheap fuel.

It remains, in my opinion, but to determine the permanency of the supply of this fuel to induce capital into this channel of business, and we can look in the near future for the building of vast systems of pipe lines to all manufacturing centers in this country.

There is another question I should like to have this society consider, and that is to determine the quantity of gas discharged from an orifice under heavy pressures.

Professor Robinson, of this State, and others went to Findlay last summer to make some measurements of the gas wells, and in his pamphlet he gives several examples of the pressures and discharges of same, also a most interesting account of his experiments with the Pitot tube for measuring dynamic and static pressures, and showing the very great accuracy of the Pitot tube. He settled this point by his experiments—that outside of the plane of the orifice there was no static pressure, while inside there was both static and dynamic. In other words, at the plane of the orifice the static pressure becomes dynamic, and does work.

We will consider one of the examples given in his book, the Karg well. The pressure at the end of a 4 inch pipe when the valve was full open was 15 pounds per square inch. From this he calculates by the adiabatic formula the velocity of flow to be 1,513 feet per second, and as the area of 4 inch pipe is 0.0873 square foot, the discharge per second would be 132 cubic feet, or 12,000,000 cubic feet per 24 hours. What is this velocity in this case?

If we calculate the velocities of fluids of 0.6 specific gravity and 1.2 specific gravity, under pressures of 15 pounds per square inch, assuming each fluid as incompressible, the velocities would be 1,778 feet and 1,244 feet. If we add these and divide by 2, we have an average velocity of 1,511 feet per second. This is the average velocity of flow, but is it, as he makes it, the average velocity for a gas of 0.6 density? Is it not the velocity for a gas of average density between 0.6 and 1.2, which would make the discharge 18,000,000 instead of 12,000,000 cubic feet per day? That it is surely more than 12,000,000 I think I can clearly prove.

If the gas was incompressible and of specific gravity 0.6, its velocity of flow would be, under 15 pounds pressure, 1,778 feet per second, and quantity discharged 13,500,000 cubic feet.

From the formula  $V = \sqrt{2gh}$  we have the velocity varies directly as the square root of the height, the height varies inversely as the densities, and therefore the weight of fluid flowing per second would vary inversely as the square root of the height. Thus a greater weight of fluid would flow per second from a pressure of one pound on water than from one pound pressure on air, or from one pound on gas of specific gravity 1.2 than from one pound on gas of specific gravity 0.6, and that this would be inversely as to the square roots of the heights, which in this case would be as  $\sqrt{1} : \sqrt{2}$  or 18,000,000 cubic feet per day. Again, take gas specific gravity 0.6 under one pound pressure, velocity would be 456 feet per second. Assuming one square foot area of orifice and one cubic foot of gas, specific gravity 0.6 = one pound in weight, the weight of flow would be 456 pounds per second; gas at specific gravity 1.2 under one pound pressure, velocity would be 318 feet per second, and weight  $318 \times 2 = 636$  pounds per second.

Calculated by the adiabatic formula, your velocity would be 430 feet per second, and by Prof. Robinson's method but 430 pounds, 26 pounds less than 456 pounds, which must be wrong. To me it would seem to be correct to calculate the velocity of flow due to pressure and density, multiply this velocity by the number of times the gas is in density greater than gas is at atmospheric density, then by area of opening, etc. Thus 15 pounds pressure its density would be 1.2 and velocity

1,244 feet per second, multiply 1,244 by  $\frac{1.2}{0.6} = 2 \times 1,244$

we would have  $2,488 \times 0.0873 \times 86,400$ , we would have 18,000,000 cubic feet discharge per day.

There is still another method of proof. Calculate the initial velocity by this formula where the length of pipe is quite short:

$$V_0 = \sqrt{\frac{g \times d(P_0 - P_1)}{P_1}} \left( \frac{4L}{d} + \log \frac{P_1}{P_0} \right)$$



$g = 32$ .  
 $ct = 47,000$ .  
 $d = \text{diam. in feet}$ .  
 $l = \text{length in feet pipe}$ .  
 $s = \text{coef. friction, } 0.006$ .  
 $P_0 \text{ and } P_1 = \text{initial and terminal pressures per square foot above vacuo}$ .

The terminal pressure in this case is 15 pounds, or 29.6 pounds above vacuo. The initial pressure say for a length of 10 feet can be figured by calculating the friction loss in that distance. The following formula will give you the weight of the fluid flowing per second:

$$w = \frac{n}{4} \sqrt{\frac{g d^5 (P_0^2 - P_1^2)}{\left( \frac{4l}{d} + \log \frac{P_0}{P_1} \right) ct}}$$

where  $n = 3.1416$ .

If you will work this by this formula, you will find the weight of fluid flowing per second to be 9.6 pounds, which would be the weight of 210 cubic feet of gas, specific gravity 0.6, or a discharge of 18,000,000 cubic feet per day.—*Jour. Assn. of Eng. Societies*.

#### HYDRAULIC DRILLING MACHINERY.

RECENT papers and discussions on the application of electric power to driving drilling machinery, at the best only leave the reader somewhat skeptical as to the economy, to say nothing of the practical feasibility of thus finishing *in situ* the great amount of drilling which cannot be done during the earlier stages of the construction of ships, bridges, boilers, etc.

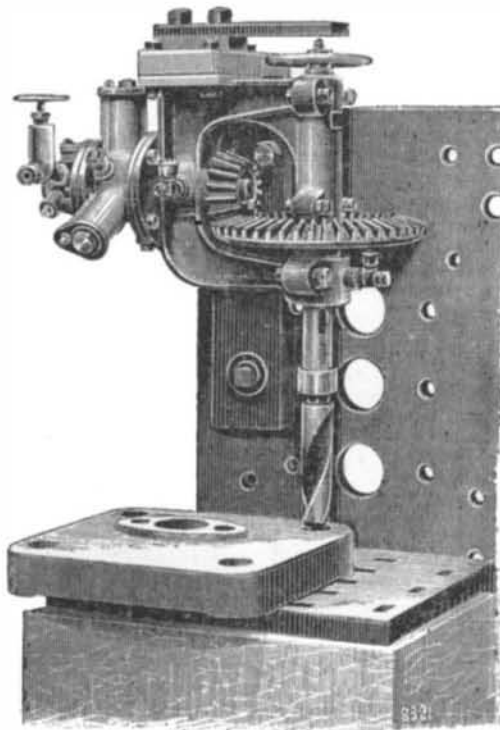
No doubt, however, exists as to the practical success and the economy in working results when this drilling is done by hydraulic power. For some years past a great amount of work of this kind has been done in the French naval dockyards by the very neat hydraulic drilling engines of which we give two illustrations.

Between thirty and forty of these machines have been successfully introduced into France by Mr. Henry Chapman, of Paris. The illustrations are so clear that but little explanation is necessary, especially as we reproduced a paper read by the inventor, in our issue of February 11, 1887. In one arrangement a three cylinder engine is used for driving a drill direct. This is attached temporarily to a bracket, for drilling work—for example, on a vise bench—away from the shops. The whole affair is so light, weighing but 60 lb. or 70 lb., that it can be used in connection with an ordinary hand ratchet drill head. Hydraulic pressure at 1,500 lb. per square inch generally (but also sometimes at 750 lb. or 1,000 lb. per square inch) is conveyed to the drilling engine by means of special flexible copper tubing.

There is no more difficulty in attaching this gear to the plating on a ship's side than is experienced in the case of hand drilling, while the speed of working when once fixed is nearly 10 to 1 in favor of hydraulic work. In another application the drill head is still lighter, the power being transmitted from the engine to the drill by means of a Stow flexible shaft. The necessary speed for the flexible shaft is obtained by gearing up at the engine end and reducing again at the drill head. As shown on this illustration, only a very rough and ready bracket is required for the drill. The engine itself is simply placed on the scaffolding at the side of the ship. There is no risk here of the sudden disappearance of the whole apparatus below, since the attachment of the drill head is quite independent of the hydraulic pressure. In addition to the advantages obtained in the more accurate execution of the work, especially when several thicknesses have to be drilled in position, there is also the great saving in labor by

reason of not having the plates, etc., to mark off, take to the shop, and put back in place again. The experience gained by the use of these drills on board large armorclads built on the cellular system goes to prove that 25 per cent. more holes can be drilled by them in the same time than can be done when the work has to be done in stationary machines in the shops, and that this class of work is done by them at seven times the speed obtainable by hand work.

For some time previous to M. Berrier-Fontaine reading the paper above referred to, Mr. Tweddell, of Westminster, had supplied some of his drilling machines to the Elswick firm for use on her Majesty's ironclad *Victoria*. They were very successful. One of these machines was used for drilling in the first place a 1 in. hole through two thicknesses of steel, 1½ in. and



¾ in., or 2¼ in. in all; the 1 in. hole having been put through, the drill was withdrawn and a hole knifed out to 3½ in. in diameter. These operations were completed in 12½ minutes, the time previously required by hand being fully three hours. A second machine was used for enlarging the holes from the inside to 5¼ in. in diameter through 2¼ in. thickness of steel. The machine had to be fixed in a most cramped position in the wings, and it being quite dark, all work had to be done by aid of the electric light. This machine did its work in one hour, as against nine hours by hand.

There is, indeed, a considerable field for the use of these drilling engines in workshops. In one boiler shop in the North of England the cost of drilling a large number of holes in boilers was at once reduced to 4d. per dozen instead of 1s. 4d., the cost by hand.

The type of engine used is the "Brotherhood" three-cylinder, with which our readers are sufficiently familiar. The probable extension of the use of hydraulic pressure for rotary engines was favorably discussed in connection with a letter addressed to this journal by the same engineer some time before on this subject.

It is not too much to say that from time to time in

many branches of work "hydraulic machine tools" prove themselves to possess unexpected economical advantages, while their introduction by Mr. Tweddell has at the same time done much to relieve workmen of much unnecessary labor.—*Engineering*.

#### RIBBON INDUSTRY OF ST. ETIENNE.

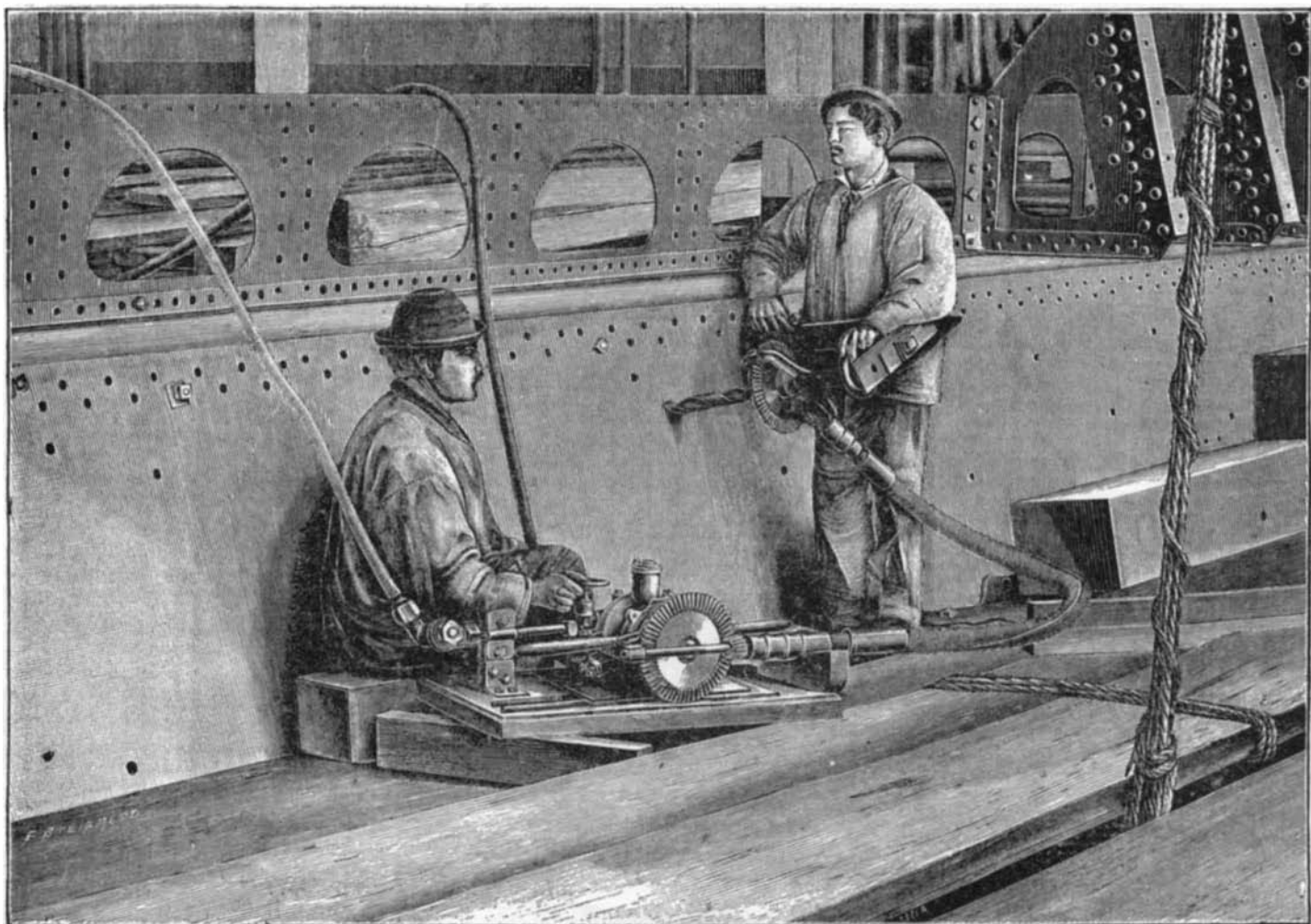
THE United States commercial agent at St. Etienne says that the ribbon industry, which was introduced into St. Etienne in the tenth century, was for a long time inferior to that of St. Chamond, where, at present, however, only special articles, such as braids, for example, are made. It is at St. Etienne exclusively that has existed for forty years the public test for silk destined to be manufactured into ribbons. The manufacture of velvets and ribbons absorbs annually from 5,000 to 6,000 kilogrammes of silk, representing a value of from 30,000,000 to 35,000,000 francs. The value of ribbons manufactured is from 70,000,000 to 80,000,000 francs.

The *rubannerie*, or ribbon industry of St. Etienne, is carried on by about 250 manufacturers, who are engaged in making many different articles, such as plain, black, colored, and figured ribbons, velvets, elastic goods, trimmings, braids, cravats, cords, galloons, etc. These manufacturers employ 18,000 looms and 50,000 workmen. The greater part of the looms of St. Etienne are worked by hand, and belong to the workmen themselves, who own small factories of from two to four looms. These looms are generally very well arranged, and perform the work well, and the manufacturers of St. Etienne, in view of the constant changes of fashion, find a great advantage in this arrangement. A manufacturer who creates a new article finds looms to produce it at a smaller cost than if he had extensive works and were obliged to exchange all his machinery. Looms for velvet generally belong to the manufacturer, as well as those for the fabrication of elastic ribbons, braids, etc.

It is estimated that the number of looms worked by steam or water power amounts to 2,000 or 3,000. There is no fixed rate of pay for workmen, as it varies according to the demand. Each ribbon requires a special agreement between employer and employe. While one man with a loom able to produce the article in vogue will gain from 10 to 20 francs a day, another with a loom producing a less fashionable fabric will make but 2 to 3 francs.

Until the year 1872, Mr. Coleman says that work was regular enough at St. Etienne, economical workmen grew rich, and most of the houses in the city were built by them, but since then the condition of the workmen has been less favorable, wages have been lower, and many have been out of employment. The ribbon production of St. Etienne formerly amounted to 110,000,000 francs yearly. This included braids also, which are now principally manufactured at St. Chamond. At the present day, the combined production of St. Etienne and St. Chamond is estimated at a sum not exceeding 90,000,000 francs. Until the year 1872, two-thirds of the ribbons manufactured were for exportation. At the present day those destined for exportation do not exceed one-third.

In some parts of Germany and Austria, natural pumice stone has been superseded by an artificial stone, to which a suitable shape can be given and different degrees of fineness of grain obtained, which allows the stone to be used in all the industries where natural pumice stone was formerly employed. The ingredients are white sand, feldspar, and fire clay, mixed in suitable proportions to obtain the desired composition, and the paste is poured into plaster moulds, being finally placed in fire clay receptacles and baked in ovens.



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