better and stronger than that from the vegetable, and much more of a preservative. By the injection of the carbolic acid from tar, mixed with a little olive oil, into the veins of the body, they might keep anatomical subjects fresh for many weeks, and it would have no effect upon the scalpel, which showed the great power and usefulness of the carbolic acid; and the only reason why it had not been extensively used for the preservation of meat was that the gaseous smell would be more or less retained.

In answer to a question from Mr. Winkworth, Mr. Grace Calvert stated that there could be no doubt that when they wished to disturb the streets, paved as Manchester was, for the gas or water pipes, that as the stones had to be raised by the pick-axe there was considerable labor required beyond that for removing the ordinary pavement. The reason why it was not more generally used he could only suppose was that each locality had its own peculiar manner of doing things; but any one who rode over the streets of Manchester could not fail noting how free they were from the jolting and reverberation felt in London and other cities.

The Chairman, in putting the motion, said he could not help remarking how deeply he sympathized with the remarks of Mr. Grace Calvert relative to the popularizing of science; and he might take that opportunity of informing them that so desirous were the Government to aid in that object that they had prevailed on Dr. Hofmann, one of the most eminent chemists of the day, to deliver a course of lectures on chemistry at the School of Mines, for the almost nominal charge of 5s. the course—instead of about £5—and sure he was that it was as little as it could be done for to remunerate the professor at all.

Mr. Grace Calvert returned thanks, and expressed the gratification he felt at what he had just heard from Dr. Playfair, trusting that the same advantages would shortly be extended to Manchester, Birmingham, and other places. Sure he was, if Dr. Playfair had but a few coadjutors as enthusiastic in extending a knowledge of science as himself, it would soon become as popularized as the most earnest lover of science could desire.

On the Flow of Water through Pipes and Orifices. B. Mr. J. LESLIE,
M. Inst. C. E.*

The author having been professionally called upon to report on a small scheme of water supply, in which it was proposed to lay down a pipe with an unusually small declivity, was induced to have a set of experiments made on the discharge of a new lead pipe of $2\frac{1}{2}$ inches diameter and 1086 feet in length, with heads varying from $\frac{3}{8}$ ths of an inch to 10 feet. This pipe was laid in a coil of about 70 feet in diameter, and was afterwards successively shortened into lengths of 540 feet, 270 feet, 100 feet, 25 feet, and 10 feet. Other experiments were also made with pipes of $1\frac{1}{4}$ inch and $1\frac{3}{4}$ inch diameter.

As much care as possible was taken to insure the escape of air; but

* From the Lond. Artizan, March 1, 1855.

the results were in some cases so anomalous as to induce the belief that complete success had not, in this respect, been always obtained.

The pipes were also carefully joined and soldered, and it was believed that, with one trivial exception, no internal obstruction had existed.

The observations, which were exceedingly numerous, were stated to have been made with much care by Mr. John Lamond, an assistant of the author; and these had been tabulated at great length, and were annexed to the paper.

The object of the author having been to institute a comparison between the deductions of hydraulicians and the results of direct experiment, he had adopted, as a standard of comparison, a formula which he believed to be due to Du Buat, and from that had calculated "the ratio of actual discharge to Du Buat's formula."

The formula employed was thus expressed:—

$$v = \frac{3000\sqrt{d}}{\sqrt{\frac{l}{h}}}$$

in which v was the velocity per minute, l the length of the pipe, increased by 50 diameters, and d the diameter of the pipe, all in feet.

For the discharge (D), in cubic feet per minute, this formula became

$$D = \frac{2356 \cdot 2 d^{\frac{5}{2}}}{\sqrt{\frac{l}{h}}}$$

Adopting this formula, the following were a few of the results obtained from the pipe $2\frac{1}{2}$ inches diameter:—

Pipe $2\frac{1}{2}$ inches diameter, 1086 long + 50 diameters = 1096 feet.

Head.		Gradient.	Observed discharge, cubic feet per minute.	Ratio of actual discharge to Du Buat's formula.
Pt.	In.			
0	0 3-16	1 in 70,256	·0444	·252
0	1	" 13,152	·2048	·503
0	$1\frac{1}{2}$	" 7,515	·241	·448
0	$2\frac{1}{2}$	" 5,260	·4412	·684
0	$5\frac{1}{2}$	" 2,391	·7407	·776
1	$5\frac{3}{4}$	" 757	1·4634	·863
2	$9\frac{1}{8}$	" 394	2·22	·945
4	$9\frac{1}{2}$	" 230	3·	·975
7	$0\frac{1}{2}$	" 156	3·53	·945
9	$11\frac{1}{8}$	" 109	4·286	·961

(It was shown in the discussion, which was only commenced, that the formula relied upon by the author was not that of Du Buat, which when applied gave results more closely approximating to those of the experiments than were obtained by the formula employed in the construction of this table.)

Numerous experiments were also made on simple orifices—on short tubes placed sometimes vertically, and sometimes horizontally—and on vertical pipes, from which coefficients of discharge, greatly at variance with accepted data, had been deduced; but it was afterwards discovered that the apparent anomaly disappeared if the active head were measured by the difference of level between the surface of the water in the cistern and the point of exit from the pipe, or the difference of level of the water in the upper and the lower cisterns.

Observations on a large scale were also made on the pipes of the Edinburgh Water Company. The "Crawley pipe" was 15 inches in diameter and 44,400 feet long, with a differential head of 226 feet. The actual discharge was 255 cubic feet per minute; whereas, by the formula, it ought to have been 294 cubic feet per minute. This pipe was, however, thirty years old, and was known to be considerably reduced in diameter by incrustation.

The "Colinton pipe" was 16 inches diameter, 29,580 feet long, with a differential head of 420 feet. The mean of fifteen observations gave an actual discharge of 571 cubic feet per minute; whereas the formula required that the discharge should have been 575 cubic feet per minute. This pipe was only eight or nine years old.

A section of the same pipe, of 25,765 feet in length, with a differential head of 230 feet, yielded, on a mean of twenty-six observations, 440 cubic feet per minute; whereas the discharge by the formula should have been 457 cubic feet per minute.

Another section of the same pipe, 3815 feet in length, with a differential head of 184 feet, yielded 1215 feet per minute, instead of 1063 expected from the formula; but a new iron pipe of $2\frac{1}{2}$ inches diameter and 1150 feet long, with about 11 feet of fall, yielded about what was due by formula to a pipe of $2\frac{1}{2}$ inches diameter.

Observations were also made on the Dundee conduit, which was 2 feet broad, with rectangular sides and a bottom of smooth stone slabs, with the following results:

Fall 1 in 1000.

Depth.	Calculated discharge.	Actual discharge.	Actual average ascertained velocity.	Velocity by floats at surface.
Inches.	Cubic feet.	Cubic feet.	Cubic feet.	Cubic feet.
6	109.	110.09	110.09	128.5
7	134.	134.83	116.	129.7
8	160.	162.16	121.6	133.1
9	186.	184.61	123.	136.7
10	213.	214.28	128.6	138.1
11	240.3	240.	131.	140.
12	268.	266.6	133.3	146.7

The formula used in this instance might be thus expressed:—

$\frac{1}{16}\sqrt{\text{hyd. mean depth} + \text{fall in feet per mile}} = \text{velocity in miles per hour.}$

The discharges by the sluices of the dock-gates of Dundee and the lock-gates of the Monkland Canal were also ascertained and tabulated. (The mean of the first seven observations gave a coefficient for feet of 5.3, and of the next four observations, omitting one imperfect observation, of 5.25, which were consistent with the received formula.)

A few experiments were also undertaken with respect to the flow of water over notch-boards; and some investigations were made for the purpose of determining whether the theoretical addition of 50 diameters to the length of the pipe was practically correct.

The author's conclusions were, that while "Du Buat's" formula gave very accurate results at moderate rates of inclination, it gave a great deal more than the actual discharge with very low gradients, and very considerably less with steep gradients.

*On Steam Boiler Explosions and the Explosive Force of Highly Heated Water.** By JOHN SEWEL, Assoc. Inst. C. E., Great Western Railway, London.†

The frequent occurrence of disastrous boiler explosions has largely attracted scientific, practical, and popular attention, and to endeavor to guide this attention to some practical benefit is the object of this paper. The investigations which take place after explosions, chiefly turn on the magnitude of the force which produced the visible destruction. That destruction it is conceived may be readily traced to the elastic force of the body of water and steam when suddenly expanding, without ascribing it to greatly increased pressure per square inch before explosion takes place. If this can be shown satisfactorily, it will lead to more attention to evidence often discredited, because it appears at variance with the effect of the explosion, and the assumed strength of the boiler. In each instance of explosion there are two opposing forces to be estimated—first, the strength of the boiler; and second, the strength of the steam. The first possesses a nearly non-elastic power of passive resistance, but the second an expansive power of vast extent, which concentrates its entire force with terrible effect on the smallest yielding of its passive opponent. Such are the antagonistic forces, and such is the difference in their relative powers; but a few remarks on each of them will render these differences more appreciable.

First, then, is the question of the real strength of the boiler. Mechanically, this depends upon the design, the materials, and the workmanship: when all three are good, a maximum strength is attained, but when any one part of them is defective, that defect rules the strength of the boiler, as bad gradients rule the tractive power of locomotives. A serious evil attends these local defects, from their becoming more acted on by the expansive and contractive motion of the boiler than the other parts. Thus slowly the cohesion of the iron is injured at these points, until some day it fails to resist a pressure it had again and again, it may be years, resisted with safety. The materials used in constructing boiler

* From the London Mining Journal, November, 1854.

† Read at the British Association Meeting, Liverpool, September, 1854.