flexible joint has been substituted. By this means the machine has been made to pass bends of a radius 3½ feet: this is shown on diagram No. 3.

It is important to have two sets of scrapers of different diameters, so that when the scraper is inserted in the main for the first time the smaller sized pistons may be used, and after the main has been partly cleared, then the larger sized pistons can be employed.

Operations of scraping must be continued during the night for two reasons, (1) to reduce the inconvenience to the public, (2) to prevent the detection of obstructions from being hindered by the noise of the traffic.

Opinion is now steadily growing in favour of providing conveniences for scraping of pipes when new water-works are contemplated. The mains should be subdivided into areas and sections having hatch boxes at suitable places: each box being placed in a man hole having a moveable cover at the street surface, and a bottom drain to remove water. Box covers may then be opened at any time without injury to the road, and without damage to the mains caused by cutting out lengths of piping. Sketch plans of hatch boxes are shown in diagram No. 4, and their position in the man-hole by diagram No. 5

The following is the descriptoin of the system of cleaning a 6in. main at Kendal, contributed to the journal by the British Waterworks Engineers' Association, by Mr. Ritson, engineer to the Kendal Corporation:—

"When everything was in readiness the scraper was inserted into the first hatch box at the reservoir. The pipe line across the fields having been previously pegged out, a number of active young men were posted along the line of main at intervals of twenty-five yards, with instructions that directly the scraper is passed underneath (which can easily be distinguished by the low rumbling sound it makes) each man had to shout to the man in advance, "Passed," and then proceed 25 yards in advance of the man farthest away, and so until the scour pipe is reached. The turncock was instructed to turn on the water at a given time, and also to listen for the inspectors' signal whistle, and follow the instructions of the code of signals given to him. The scraper moved off directly the water was turned on, but it only proceeded 130 yards when it stuck fast. When the scraper sticks its position can be located by means of a stethoscope from the sound of the water rushing past. The position of the stoppage in this case having been speedily located, the water was turned off, the main cut, and the scraper removed. It was then found that the stoppage was due to about 12 lbs of lead the result of a badly run joint. The pipes having been made good the scraper was once more inserted, and it came down as far as the scour pipe. In the evening the scraper was again set in motion, and it arrived at the second hatch box in a short space of time, bringing with it a goodly quantity of filth and corrosion.

The next day the scraper was again inserted at the reservoir in the hatchbox, and the water turned on, when an exciting chase took place, for No 2 hatchbox (a distance of 2,523 yards) was reached in 17 minutes. A good deal of corrosion came down again and the main had to be well flushed.

In the evening the scraper with knives set to 5⅜ in., and fitted with 4¾ in. diameter pistons was inserted in No. 2 hatchbox. The men were instructed to lie down at intervals of 20 yards, with ear to ground, on the line of pipes. The water was turned on and the scraper moved off gaily, the inspector following it up with his stethoscope, but after a journey of 40 yards it stuck. The sluice valve was turned off and opened suddenly in the hope of again setting it in motion, but without success. The pipes were then bared and well rapped with a hammer which had the desired effect. The scraper moved off another 40 yards and stuck again. The same operations were repeated but failed. A loosely rolled wisp of hay was inserted into the main behind the scraper and the water turned on, but all to no purpose, it had to be cut out.

On examining the interior of the main at several spots between No. 2 and 3 hatch-boxes, it was found to be so badly corroded that in some places there was barely two and a half inches of waterway through it, and as the pipes had not been treated with Dr. Angus Smith's composition, the carbuncles of oxide of iron had coalesced to such an extent, and were, moreover, so firmly fixed to the interior surface of the pipes, that it was regarded as next to impossible to scrape this length (66 yards), and a new main was laid instead.

Operations were now directed to scraping 830 yards of 4″ main, which was known to be badly corroded. It was feared, however, that the task would be both laborious and expensive, unless some means could be devised which would admit of the work being done expeditiously and well. A local blacksmith was brought into requisition, and a set of steel spring scrapers was made somewhat on the model of the 6″ scraper, but without the rear or propelling pistons, but with a ring formed in the front of the apparatus to hook on a rope. A hundred yards of ¾″ strong Manilla hemp rope, a similar length of ¾″ steam tube, a couple of cast iron clips for 4″ pipes with rubber bushes or cylinders (used for speedily joining up the ends of cut pipes), and a crab winch completed the kit. The main was cut at intervals of 90 yards. Length after length of steam tube was screwed together, and passed along the main until it emerged at the other open end. The rope was then hooked into an eye made in the front length of tube, and the whole withdrawn. One end of the rope was then attached to the drum of the winch and the other end hooked to the scraper before being inserted in the main. A piece or four inch pipe was cut to length, and the rubber brushes slipped over the ends of the cut main, the whole evenly and tightly clamped together by means of the clip joint.

A gentle stream of water was turned on and the scraper slowly drawn through the main by means of the winch. This operation was repeated twice, and the main well flushed after each scraping; and on completion the corrosion had been completely removed, and the pipes appeared almost as good as new.

The cost of scraping amounted to 6.32d per yard. Pipes coated with Dr. Angus Smith's composition can be scraped quite easily, and at cost of from 4d to 5d per yard. The success of the scraping of the 4″ main was so marked that it was determined to make another attempt upon the 6″ main where operations had ceased. Accordingly the scraper was set to full size, and inserted into No. 2 hatchbox at 10 o'clock at night. Men were posted at intervals of 10 or 12 yards on the line of main, with strict orders to listen with ear to the ground. The scraper moved forward after the water was turned on at a fairly rapid pace, and for a time was lost, but eventually located by means of the stethoscope, and the mud, filth and encrustation at No. 3 hatchbox showed that it was doing its work. After a good deal of dodging such as turning off the water and putting it on again suddenly, passing several lengths of ¾ in. steam tube down the main to try and force the scraper back a bit, at last it came into No. 3 hatchbox bringing with it a ton or more of iron rust, the shattered remains of carbuncles.

The total cost of scraping the 3,190 yards of 6″ main amounted to 4.08 per yard. The result has been that the water supply has been so much improved, *without the anticipated extensions of the mains*, that a constant supply is able to be given and the total cost under £55.

TABLE GIVING SUMMARY OF COST OF SCRAPING WATER MAINS BY PRESSURE SCRAPER.
(From Minutes of Proceedings, Inst C.E.)

Year.	Place	Diameter.	Length of main	Total.	Cost per yard	Obstruction.	Gain in delivery after scraping.
			miles yds.	£	1 d.		per cent.
1877	Oswestry	7″	1 440			Large stones, lead, and defective pipes	54.4
		6″	4 660	121	2 93		
1878	Lancaster	8″	1 1500	30	2 2	Peaty matter	56.1
1880	Durham	12″	1 586	91	9 1	Lead spade, spike, waggon spring	
1880	Bradford	18″	4 1100	634	18 6	Stones, lead, crowbar, &c	55.6
1881	Halifax N.S.	12″	1 573	91	9.3		
1882	Exeter	16″	2	192	6 5		
		12″	2				
1883 1885	Whitehaven	13″	2 1056	516	11.1	Mussels stones, lead	27.6
		11″	3 1232				
1885	Bristol	6″	1 785	35	3 3	Stones	
1886	Denbigh	6″	1 880	150	13 6	Stones, gravel, lead	
1887	Omagh	6″	2 792	53	2.9	Lead, defective castings	30 0
1887	Halifax	6″	776	21	6 5		
1888	Ulverston	6″	1	72	9.8		
1890	Dundee	15″	2	256	17 4	Wood, stones	
1890	Dumfries	9″	1	113	3	Stones	
		8″	4				
1890	Scarborough	8″	1 440	62	6.7		
1891	Newport	10″	1080	50	11 1	Lead.	
1891	Lanark	7″	6 880	75	1.57	Lead, wood stones.	33.7
1892	Roubaix (*France*)	24″	5 594	242	6.4		16ft. taken off pumping engine
1892	Burntisland	8″	3 1320	252	9 02	Piece wood 2ft 3″ x 5½″ x 5″, lead	
1893	Bridge of Allen	6″	1				35
1893	Thurso	6″	3				7
1894	Stirling	8″	3 1320			Stones, lead, broken pipe	
1894	Waterford	13″	8	211		Same	40
1895	Cuper Fife	7″	3 880	66	2.6	Piece broken pipe, rabbit	52
1895	Merthyr Tydvil	14″	5 617	318	8.01	About 400 stones.	30