The services, broken mains, unfinished supplies and leaky joints repaired account for 12,000,000 gallons waste per day, permanently stopped.

The pumpage has been reduced except in times of extremely hot or cold weather, to less than 125,000,000 gallons per day, as compared to over 160,000,000 gallons per day in 1917. Figuring the cost of pumping at $6.24 per million gallons, the average cost for the last three years, the annual saving is $68,328. Against this is the estimated charge of $25,000 per year to maintain the Pitometer Division of the Bureau.

To date the survey has cost $96,931, much of which represents permanent investment in equipment and records, or for professional services.

Including the pay of temporary inspectors, who will be employed each spring, it is estimated that the annual cost of continuing the work will be $25,000 per year.

From the survey made and results obtained it is evident that to a certain extent the house waste can be greatly reduced by house inspection controlled by pitometer measurements. When used in conjunction with selective metering the most flagrant house waste can be eliminated and the consumption reduced nearly to that obtained by universal metering and done at less expense. The pumpage can be reduced at least 20,000,000 gallons by the installation of 10,000 meters on house services where tremendous waste has been found by the survey. The installation of these meters is now proposed. A further reduction is not deemed advisable until a filtration plant is built.

THE "UNAFLOW" PUMPING ENGINE*

By D. A. DeCrow

THE "Unaflow" steam engine derives its name from the fact that the steam travels over a path into and through the steam cylinder in one direction; it does not counter-flow or return over its own path.

The "Unaflow" engine is not particularly new in principle but its successful development as a practical and economic commercial machine is quite recent and its adaptation to reciprocating pumping engine practice new. A number of inventors during the past thirty of forty years have been attracted by the "Unaflow" principle but none of them have until quite recently succeeded in perfecting its development so as to make it successful economically and commercially.

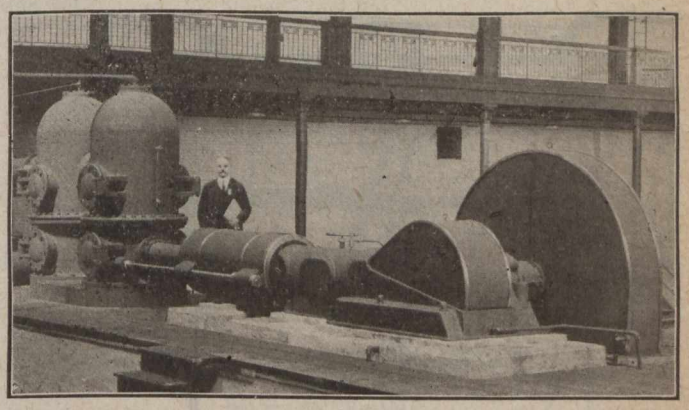
While he does not seem to have been the first, J. L. Todd is possibly the most prominent of the early inventors who attempted to apply the "Unaflow" principle to the steam engine. His first patent was a British patent issued in the year 1885. He was not able to make it a mechanical or commercial success though he spent many years and much money in the effort. About 1895, he apparently gave up trying to make a success of the pure "Unaflow" and adopted the "Dual" or double exhaust engine which was a combination of the "Unaflow" and counter-flow type; he, however, did not appear to have followed the right lines in the development of his "Dual" exhaust engine to make for unqualified success, for it has not come into general use.

After these early and on the whole unsuccessful attempts, interest in the "Unaflow" engine died out for a considerable period, but quite recently investors have been attracted to it and much experimental work has been done; Professor J. Stumpf took it up actively, overcame previous difficulties and to him undoubtedly falls the honor of making the first practical and commercially successful application of its principles to modern steam engine practice; his inventions and adaptations have been generally recognized. During the period directly previous to the beginning of the late war, many of these "Unaflow" steam engines were constructed in England and on the continent for various kinds of power service, but in the United States it has not until recently been developed and adapted for power units in conformity with American practice, activity along these lines having been restricted greatly by reason of war requirements on the engineering and manufacturing resources of the country. The war is now over, rapid progress is being made in its development, many power units have been and are being installed and a number are in successful operation.

Broadly speaking the general principle of the "Unaflow" reciprocating steam engine is that of utilizing the heat energy of the steam in the cylinder during the period of its admission, expansion and flow in one direction, the expanded steam being released or exhausted through ports or openings uncovered by the travel of the cylinder piston at that period of its stroke most remote from the point of admission; the comparatively cold expanded or exhausted steam does not counter-flow and pass through ports at or near the admission or hot end of the cylinder.

A typical "Unflow" steam cylinder and a typical set of indicator cards from a condensing "Unflow" engine are shown by the accompanying sketch.

In this sketch the piston is at one end of the stroke with the exhaust ports uncovered, the arrow indicating the path of the steam through the cylinder. It will be noted by examination of the indicator diagram that steam is admitted into the cylinder for only a very minor portion of the stroke and is then cut-off, the work performed during the remainder of the stroke being due to the expansion of the steam after the inlet valve closes. The exhaust opens when the piston, which is much longer than the ordinary engine steam piston, travels past and uncovers the exhaust ports midway between the two ends of the cylinder.



"Unaflow" Pumping Engine Installed in Porter Ave. Station, Buffalo, Especially for Inspection by Delegates to Water Works Convention.

Beginning with the steam in the cylinder there is practically no change of temperature until the point of cut-off. After cut-off, expansion takes place with a consequent drop in temperature and at this time condensation begins, due to the changing of heat into work. As the cylinder head is jacketed with high steam no condensation takes place on the walls of the head, but the condensation is on the wall of the piston, which is comparatively cool and adjacent thereto, so that at the end of the stroke when the piston uncovers the exhaust ports the moisture of condensation is mostly at the exhaust end of the cylinder, and as the steam expanding away from the cylinder head rushes out through the exhaust port, it carries the moisture with it.

At this time there is a sudden drop of temperature in the cylinder due to the sudden drop of pressure, but as the inlet end of the cylinder is dry it does not lose its temperature, the flow of heat from a dry surface being slow and there is not sufficient time for any perceptible drop in temperature of these dry walls. The exhaust port is covered by the piston on the return stroke, trapping in the cylinder comparatively dry steam partially superheated; as the walls of the cylinders have retained their heat, the heat of compression is not absorbed either by moisture or by cold walls as in the case of a counter-flow engine and the

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