which has the effect of rendering the leather more flexible, and the surface perfectly uniform. These operations are repeated two or three times, when the leather is ready for soles. Before the tanned hides intended for shoe-soles are considered fit for that purpose, they must be slightly compressed and softened, so as to again diminish their permeability to water. This was formerly effected by beating with a hammer called the mace, but of late years this slow process has been superseded by compressing machines; and I believe those most appreciated in the trade were invented by Messrs. Cox and Welsh, and Messrs. Iran and Schloss.

To be Continued.

Lake's Differential Steam Engine. By FRANCIS CAMPIN, C. E.

From the London Artizan, March, 1865.

SIR:—In the differential steam engine, of which the annexed diagram exhibits a vertical section, great simplicity of construction is achieved, in addition to increased economy in consumption of steam. The engine comprises two cylinders of different diameter, so arranged as to be axially in the same straight line; these cylinders are furnished with pistons, as shown in the sketch, that in the small cylinder being perforated round its periphery between the packing rings. The interior of the piston communicates with a trunk or chamber which connects it to the large piston in the expansion cylinder, which is open at the bottom. When the small piston is at the bottom of the stroke, as illustrated,

the holes in its periphery correspond to others in the curved lateral steam passages, of which the other ends open into the cylinder a little higher up, and through which steam from above the small piston flows, filling the trunk and space below the large or expansion piston.

Let us now examine the effect of the working of the engine, assuming the following dimensions: Diameter of small cylinder 8 ins.; of large cylinder 16 ins.; stroke 1 foot; cubic contents of trunk equal those of the small cylinder; pressure of steam above the atmosphere, 60 lbs. per square inch, or absolute pressure, 75 lbs. per square inch.

The effective area of the small piston may be taken as 50 square inches; that of the large piston being four times as much, or 200 square inches. First we will consider the work done in the down stroke through which the steam acts on the small piston with its full force: we have 50 square inches $\times$ 75 lbs. per square inch $\times$ 1 foot = 3750 foot lbs.; the useless resistance is the atmospheric pressure, or 50 square ins. $\times$ 15 lbs. $\times$ 1 foot = 750 foot lbs., which, deducted from the gross work, leaves as effective work 3000 foot lbs. done during the down stroke. In the up or expansion stroke, the steam supply is cut off as soon as the small piston

has repassed the ends of the lateral steam passages, and then the steam in the trunk continues to expand during the remainder of the stroke, and because the large cylinder is four times the size of the trunk, which the contents equal those of the small cylinder,) it is evident steam will expand five times, or down to a pressure of 15 lbs per inch absolute; for that quantity of steam which at the commencement of the stroke filled only the trunk, will, at the end of the same stroke fill the trunk, and in addition thereto the large cylinder. The mean pressure in the up stroke will therefore be about 45 lbs. per square inch; so the gross work done by the steam in the up stroke will $200 \text{ square ins.} \times 45 \text{ lbs.} \times 1 \text{ foot} = 9000 \text{ foot lbs.}$ From this may be deducted the prejudicial resistances: first, there is the whole pressure of steam on the small piston (for the small cylinder is always in communication with the boiler; this represents 3750 foot lbs. work the stroke. There is also the atmospheric pressure on the top of the annular part of the large piston,— $150 \text{ sq. ins.} \times 15 \text{ lbs.} \times 1 \text{ foot} = 2250 \text{ foot lbs.}$, making the total prejudicial resistances 6000 foot lbs. in the up stroke, leaving for effective work $9000 - 6000 = 3000 \text{ foot lbs.}$, exactly the same as in the down stroke. Thus in one revolution of the engine 6000 foot lbs. of work would be done. As soon as steam in the large cylinder has expanded down to 15 lbs. per square inch, a self-acting valve in the exhaust passage which has hitherto been kept closed by the pressure of steam against it, falls open of its own weight, or by pressure of a light spring; so the steam escapes from under the large piston, and another down stroke is made, at the end of which the closing of the exhaust valve is produced by the pressure of the steam admitted to the large cylinder, or by a tappet. At the end of the up stroke the steam is not all discharged from the large cylinder, as the trunk will remain full at atmospheric pressure; so the steam actually used for each double stroke of the engine will be only four-fifths of a trunk full, or 0.28 cubic feet. If we suppose the engine to be running at 35 revolutions per minute, 588 cubic feet of steam per hour will be used, or 92 cubic feet per horse power per hour (the power, in the instance cited, being 6.39 horses.) This, at 75 lb absolute pressure per square inch, is generated from 15 lbs. of water per hour, with a consumption of 21 lbs. of coal—hence the consumption of fuel will be but 2 lbs. of coal per indicated horse power per hour, corresponding to a duty of 110,000,000 foot lbs. per 112 lb of coals consumed. Comparing this with the Cornish engines, we find the results favorable to the differential engine; for of the 34 engines reported in Cornwall for September, 1864, the average duty was but 49,800,000 foot lbs., and even the highest duty was only 70,800,000 foot lbs.; and the greatest economy yet attained by any Cornish engine over long periods of working was not more than 109,000,000 foot lbs. per 112 lbs. of Newcastle coal consumed.

It may be further remarked that in the manufacture of the differential engine comparatively little labor would be required, as there scarcely any fitting about it, and there is but one valve (that being self-acting), and no glands nor eccentrics.