way. In these cases the 16-candle power lamp is used for the standard.

There are two methods of distributing electricity in practical work, one in which the current is kept constant and the force is varied according to the amount of work to be done; the other in which the force is kept constant and the quantity is varied in proportion to the work done. Suppose we had at the top of a hill a supply of water which we wish to use for power, and suppose that on one side of this hill we could descend into a valley in the depth of 100 feet, and on the other side we could only descend 10 feet, and suppose, furthermore, that we wished to operate ten water wheels from this water power. If we put these ten wheels side by side and connect them by a pipe large enough to supply them all, the pressure of the water would remain constant and the quantity flowing would depend upon the number of water wheels working; or, in other words, upon the amount of work done. On the other hand, supposing we put these wheels on the other side of the hill, one wheel below the other, ten feet apart, and connect them with a pipe one after the other. To make this comparison complete it must be considered that each wheel is on a shelf or terrace in so far as the pipe is not in a straight line up and down the hill, and because each wheel is supposed to require a head of 10 feet only. Now, in this case the quantity of water passing remains constant, whereas the pressure or total drop can be considered as practically proportional to the number of wheels working. To operate all ten wheels on this system requires a total fall of 100 feet, and the same water works all the wheels; whereas, to work the ten wheels by the other system requires a fall of only 10 feet, but each wheel takes its own separate supply of water. Although this comparison is a little difficult, it is essentially the same as the two methods of distributing power by electricity. If, for instance, we have ten lamps, each of which requires a current of 10 amperes in quantity with a pressure of 10 volts, and we connect these lamps one after the other, then the same current of 10 amperes would work all the lamps, but the force would be 10 times 10 volts, or 100 volts, whereas if we connect these lamps side by side, then each would require its own supply of electricity, the same pressure would work them all, but it would require 10 times as much electricity to supply them. *Electrical Industries.*

THE WORK THAT IS IN STEAM.

THERE is only a certain amount of work that can be got out of steam, no more, says a writer in *Power and Transmission*, and without expansion there is much less than there is with. It would be well for us to be able to figure out just how much heat and work there are in steam at any desired pressure, both with and without expansion.

The maximum work that can be got out of steam without expansion may be found by multiplying 144 by the pressure in lbs. per square inch in vacuum and by the volume of steam at the desired pressure, as compared with that of water at the maximum density of 39° F., then dividing by the heat units per cubic foot of steam from 32° to the desired temperature, and by the volume of steam of the corresponding temperature compared with that of water at the maximum density of 39° F. This volume is got by Fairbairn & Tate's formula:

$$V = 25.02 + \frac{49513}{P + 0.72};$$

in which V represents the volume due to the temperature and P is the total steam pressure in inches of mercury.

Suppose that we wish to know how much maximum work there is in steam at 60 pounds above vacuum, or rather more than 45 pounds per square inch by the gauge. That maximum work will be

$$\frac{144 \times 60 \times (428.32 - 1)}{170.58 \times 428.32} = (144 \times 60 \times 427.32)$$

$\div (170.58 \times 428.32)$ equals say 50.5 foot lbs., or $50.5 \div 772 = 6.54$ per cent. of the total power.

Suppose that we increase the steam pressure to 120 pounds total, or pounds above vacuum, then we shall have the maximum amount of work

$144 \times 120 \times (227.56 - 1) = 144 \times 120 \times 226.325.20 \times 227.56$

$56) \div (325.20 \times 227.56) = 52.0$ foot pounds, about 6.85 per cent. of the total work. Thus by doubling the steam pressure above vacuum we have increased the maximum amount of work about $5\frac{1}{2}$ per cent.

When it comes to figuring out the maximum amount of work which can be realized per heat unit in steam with expansion, we must multiply 144 by the total pressure in pounds per square inch, by the volume compared with that of water of maximum density, and by 2.31 times the logarithm of the stroke of the piston, divided by the period of full steam, plus 1; and divide this by the same elements as before, the heat units per cubic foot of steam from 32° to the temperature of the steam used and the volume of the steam compared with that of water at 39° Fah.

This is a very "long-winded" rule and is much better expressed by a formula:

$$E = \frac{144P(V-1)(2.31 \log. S + 1)}{HV}$$

Instead of 2.31 times the logarithm of the relation between full stroke and the time of full steam, the expression "hyperbolic logarithm" may be used.

To work out a couple of examples under this rule and formula: Suppose that we have steam as before of 60 pounds pressure above vacuum or about 45 pounds by the gauge; and that the cut off is at $\frac{1}{4}$ the stroke. Leaving out clearance and all other disturbing and complicating causes, we get the following:

$V - 1 = 427.32$

1 + hyperbolic logarithm of 4 = 2.38629

$H = 170.58$. Then we have

$$\frac{144 \times 60 \times 427.32 \times 2.38629}{170.58 \times 428.32} = 120.58$$

which is, of course, just 2.38629 times the result that we got with steam at 60 pounds and no expansion.

Now, trying steam at 120 pounds pressure above vacuum, we have

$$\frac{144 \times 120 \times 226.56 \times 2.38629}{325.20 \times 227.56} = 126.2$$

or, of course just 3.38629 times the proportion where there was no expansion but the same pressure above vacuum.

Now we will try cutting off at $\frac{1}{8}$ instead of at $\frac{1}{4}$. The expansion ratio is 8, the hyperbolic logarithm of which is 2.0794, so that we shall have with eight-fold expansion, 3.0794 times the duty that we had without any expansion.

We may compare these six results with advantage:

	Proportion of work Realized.	
	60 lbs. Pres.	120 lbs. Pres.
No expansion at all	6.5	6.8
Four-fold expansion	15.6	16.3
Eight-fold expansion	20.1	21.1

HEATING FEED-WATER.

THERE is something very remarkable in the slowness with which steam users recognize the great saving they may make in their weekly coal bill by the use of feed-water heaters. In many places the gain, which might be secured at no very great outlay, would make all the difference between a dividend and no dividend. At a meeting of a paper manufacturing company a short time since, it was mentioned that this one firm used 200 tons of coal per week, and that the recent increase in the price of coal made an increase of £2,600 per year in the fuel bill, which made a reduction of 4 per cent. in the dividend, or from 12 to 8 per cent. This is only one of many works wherein such large quantities of fuel are consumed, and it is well-known to engineers that it is the exception rather than the rule to heat the feed water on its way to the boilers. Yet by this means some firms are making a saving which represents a large income. A very moderate estimate of the value of a heater which raises the feed-water from a normal temperature to about 200 degrees, is the saving of 10 per cent. of the fuel used. This, where coal costs a £1 per ton, and where, as in the above case, 220 tons per week are used, represents a yearly saving of £1,250 per year; or probably a dividend of from 50 per cent. to 60 per cent. per year on the capital expended on the feed water heaters. *The Engineer.*

In the recent technological examination in England in which scholars compete, it is a sign of the times that electric lighting attracted more than twice as many as telegraphy.