And the whole power required will be the sum of these; therefore,

$$P = \frac{w_1}{2} + \frac{w_2}{2^2} + \ldots + \frac{w_n}{2^n} + \frac{W}{2^n}, \text{ or}$$

$$W = 2^n P - \left(2^{n-1} w_1 + 2^{n-2} w_2 + \ldots + w_n\right)$$

The weight of the pullies therefore lessens the advantage of the machine.

Cor. If the weight of each pully be the same (w), then

$$W = 2^n P - (2^{n-1} + 2^{n-2} + \ldots + 1)\, w$$

$$= 2^n P - (2^n - 1)\, w.$$

68. *Third system of pullies.* Third system, Fig. 9.

Each pully hangs by a separate string which is attached to a bar or block carrying the weight, and the free portions of all the strings are parallel, and therefore vertical.

This is the second system turned upside down, the weight becoming a fixture, and the beam to which the strings are attached becoming a moveable bar carrying a weight, and the mechanical advantage might be inferred from the preceding. The pressure supported by the beam in the second system is the sum of the tensions of the strings, that is,

$P + 2P + 2^2 P + \ldots$ to n terms, $= (2^n - 1) P$, and this becomes the weight W in the third system. Therefore,

$$W = (2^n - 1) P.$$

The last pully (A_n), however, becomes fixed, so that the number of moveable pullies is only $(n - 1)$. Making n the number of *moveable* pullies we have

$$W = (2^{n+1} - 1) P.$$

The following is an independent investigation for this case.

Let $A_1, A_2, A_3, \ldots A_n$, be the pullies, n being their number exclusive of the last one A, which is fixed, and $\overline{n+1}$ the number of strings.