the fact that the annual production of the chemical industries of the United States is already nearly equal in value to our agricultural products. Let us, however, not forget that these benefits have come, as many more will follow, because chemists have never faltered in pursuing truth for years through the labyrinth of difficult researches with no better guide than the slender and often broken thread of an hypothesis. Turgot has said: "What I admire in Christopher Columbus is not that he discovered the new world but that he went to look for it on the faith of an idea."

EARTH PRESSURES.*

(Continued From Last Week.)

To show that the surcharge of a slope should not increase the horizontal pressure against a vertical surface, consider the cylinders 1 A, 2 A, 3 A, 1 B and 2 B of a d c. While 1 A evidently holds the whole tier 2 A, 3 A, 4 A — 9 A in position, it does not carry any more weight or thrust than if only 1 A, 2 A and 2 B were considered. 1 A and 1 B carry 2 A with points of contact or support at s and n. (See enlarged sketch of cylinders at upper left-hand corner.) Remove the cylinder 1 A, then to maintain 2 A in position and equilibrium, substitute a horizontal force P acting through the centre of 2 A. Then 2 A is maintained in position and equilibrium by P and the weight W, acting through their respective lever arms, with n the point of contact as the centre of moments. Total moments about n = O = Py—Wx. From which $P = \frac{Wx}{y}$. But 2 A carries one-half the weight of 3 A applied at their point of contact m. By construction, m is vertically above n. Therefore the weight from 3 A applied at m will pass through the point of support n. As n is the centre of moments for 2 A, the weight from 3A and passing through n will not disturb the equilibrium of 2 A already established. The horizontal thrust P will not be increased by the added weight at the point of contact, so long as the angle of friction between the surfaces is greater than 30°. The other half of the weight of 3 A is carried by 2 B from the point of contact o and passed on to r without disturbing the equilibrium of 2B. Thus it is seen that the cylinders above do not disturb the equilibrium or produce an added horizontal thrust in those below, but only contribute their weight to increase the vertical load. This is as it should be, for the particles on a natural slope to contribute an added horizontal thrust to those below, would imply an arching effect which does not exist. In other words, if arching of that kind took place, we would have the anomaly of the toe of the natural slope of an embankment carrying a load greater than the weight of the material in the vertical projection above.

Returning to the bin A B B_1 A_1 of Fig. 8. Suppose a prism A N A_1 is piled in the bottom of the bin. As the toes of the slopes only reach to A and A_1 there is no pressure developed in the sides A B or A_1 B_1. If a plane is passed vertically through N, however, we should expect to get the full developed horizontal pressure for the vertical height of N above the base A A_1. Compare this with the side c d of the pile of cylinders. The horizontal thrust from 2 E is no more with all of the cylinders above in position than it is when they are removed. The only cylinders producing horizontal thrust on the side c d are 2 E, 4 D, 6 C and 8 B. If now the bin is filled up to the level of N, the pressure should be the same on the side of the bin A B as on the vertical plane passing through N. In other words, the horizontal pressure against any vertical plane passed through the level fill of the height N should be the same as against the side A B. The resultant of the developed pressure within the mass should be at right angles to the force of gravity.

To take still another view. Suppose the bin is filled to the level of N and then gradually removed from one side, say first to the slope A_1 N. Then continue the removal until the slope leaves the side A B at the level of N. At what point can we say the pressure against the side A B began to be less than when the bin was full up to the level N? According to the sliding prism theory is should be when the line A D or plane of rupture is reached. But in reality has the plane of rupture anything to do with the development of horizontal pressure? Must we conclude that a bin must be wide enough for the plane of rupture A D to pass out before reaching or intersecting the side A_1 B_1 before the full pressure of the retained material can be developed against the side A B? Under that conception what is the character of the pressure developed against the side A_1 B_1? The assumptions of that theory seem at least unusual, but still do not give as great values for surcharge as given by Rankine.

In the lower right-hand corner is given a table showing the values of the earth pressure E and the angle δ which the resultant makes with the horizontal. The results are from Rankine, Rebhann, Trautwine, and the developed pressure theory. The assumptions are h = 40 ft., side A A_1 = 10 ft. γ = 100 lb. per cu. ft., $\phi = 45°$, $\alpha = 0°$, and $\epsilon = 0°$ or level in one case and ϕ or 45° in the other. It will be noted that both Rankine and Rebhann give about three times, and Trautwine nearly twice the amount of pressure E, for surcharge over what they give without. The value of E by the developed pressure theory is considered the same either with or without surcharge and is not far from a mean of the values given by the other theories when $\epsilon = 0°$ and $\epsilon = 45°$. It should be noted that there is little agreement between the different theories for the value of the single δ which the resultant makes with the horizontal.

2nd. For negative values of α (back batter toward the fill.)

With back batter toward the fill or α negative, the formula employed for obtaining the earth pressure is:

$$E = \frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ \phi}{\cos.\ \alpha}\right)$$

The values of E at the limits of ϕ and α are:

$$\text{for } \phi = 0° \text{ and } \alpha = 0°, E = \frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ \phi}{\cos.\ \alpha}\right) = \frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ 0°}{\cos.\ 0°}\right)$$

$$= \frac{h^2\gamma}{2}\left(1 - 0\right) = \frac{h^2\gamma}{2} = \text{hydrostatic pressure.}$$

$$\text{for } \phi = 90° \text{ and } \alpha = 0°, E = \frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ \phi}{\cos.\ \alpha}\right) = \frac{h^2\gamma}{2}\left(1 - \frac{\sin. 90°}{\cos.\ 0°}\right)$$

$$= \frac{h^2\gamma}{2}\left(1 - \frac{1}{1}\right) = 0.$$

For α = the complement of ϕ (or when the back batter coincides with the natural slope, $\alpha = 90° - \phi$), then E =

$$\frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ \phi}{\cos.\ [90° - \phi]}\right) = \frac{h^2\gamma}{2}\left(1 - \frac{\sin.\ \phi}{(\cos.\ \text{complement}\ \phi = \sin.\ \phi)}\right)$$

$$= \frac{h^2\gamma}{2}(1 - 1) = 0$$

Values of C, Developed Pressure Theory, Compared With Those from Rankine and Rebhann.

This second set of comparisons is made at the risk of some restatements.