$$\text{Therefore, } C\,\Omega = \frac{W}{g}(\mu_1\, p_1 - \mu_2\, p_2)\,\Omega.$$

In a turbine designed for maximum efficiency u_2 should be zero; i.e., water should have no component in a direction perpendicular to radius of wheel, and then

$$C\,\Omega = \frac{W}{g}\mu_1\; p_1\;\Omega.$$

Now p_1 = radius of wheel at inlet. Therefore, $p_1\,\Omega = V_1$ = velocity of rim of wheel at inlet.

$$\text{Therefore, work done} = \frac{W}{g}\,\mu_1\; V_1 \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (3)$$

Now let Q = volume of water passing per second.
H = available head for turbine.
and w = weight per unit volume of water = 62.A pounds per cubic foot.

Then $W = Q\,w$,

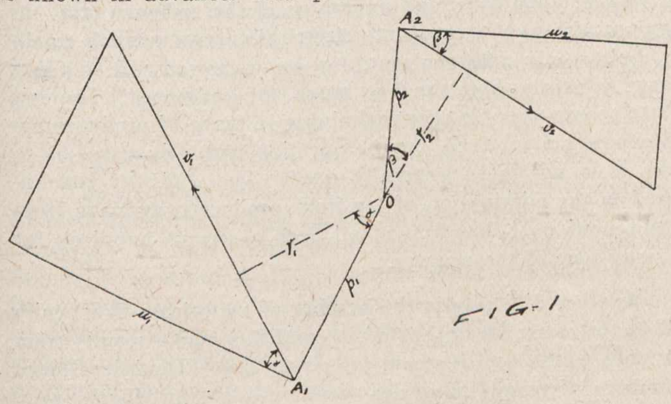
$$\text{and work done} = \frac{Q\,w}{g}\,V_1\; w_1 \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Also work supplied $= Q\,w\,H$.

$$\text{Therefore, } E = \frac{Q\,w\,V_1\,\mu_1}{g\,Q\,w\,H} = \frac{V_1\,\mu_1}{g\,H} \quad\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

Where E = the Hydraulic Efficiency μ_1 is often called the "velocity of whirl."

When a turbine is to be designed, the available head = H is known in advance. The preliminary assumptions usually



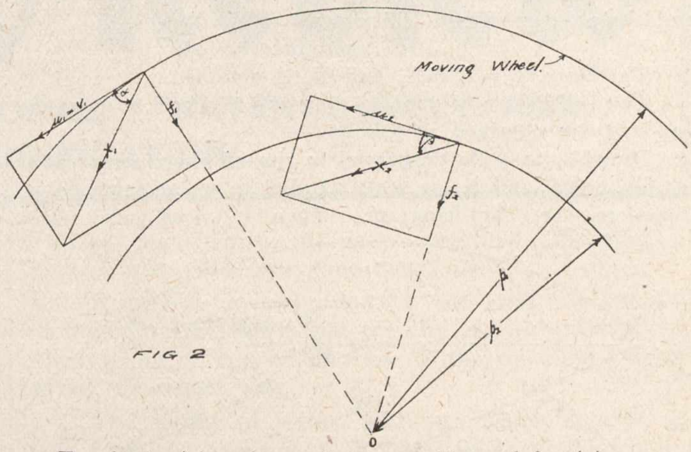
made are the volume of water passing per second, the angular velocity of wheel (*or* radius of wheel), breadth of wheel at inlet, and the circumferential velocity v_1. As the best speed of wheel partly depends on frictional losses, v_1 is often made $= 0.6\sqrt{2gH}$.

The following empirical values have been justified by experience:—

$\frac{p_2}{p_1}$ varies from 0.6 to 0.8, $V_1 = 0.6\sqrt{2gH}$ and $A_1 = A_2$

Let f_1 = velocity flow at inlet.
f_2 = velocity flow at outlet.
μ_1 = velocity whirl at inlet.
μ_2 = velocity whirl at outlet.
x_1 = abs. velocity jet at inlet.
x_2 = abs. velocity jet at outlet.
A_1 and A_2 = areas at inlet and outlet, respectively.
V_1 = velocity rim of wheel at inlet.
V_2 = velocity rim of wheel at outlet.
Q = volume passing in cubic feet per second.
w = weight per unit volume = 62.4 pounds per cubic foot.
α and β = angles between abs. velocity jet and velocity wheel rim at inlet and outlet, respectively.
b_1 and b_2 = breadth wheel perpendicular to paper at inlet and outlet.
p_1 and p_2 = radii at inlet and outlet.

The turbine, to be of maximum efficiency, necessitates: (1) No shock when water enters wheel, and (2) the water to leave the turbine radially.



To obtain (1) we must have $\mu_1 = V_1$, and for (2) $\mu_2 = 0$.
Also $f_1 = f_2$ (neglecting friction on vane).
The work done per pound of water from equation

$$(3) = \frac{V_1\,\mu_1}{g} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (6)$$

$$\text{and work lost at exit per pound water} = \frac{f_2^2}{2g} \quad\ldots\ldots\ldots\ldots \quad (7)$$

$$\text{Then } H = \frac{V_1\,\mu_1}{g} + \frac{f_2^2}{2g}$$

And since $\mu_1 = V_1$,

$$\text{Therefore, } H = \frac{V_1^2}{g} + \frac{f_2^2}{2g} \quad\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (8)$$

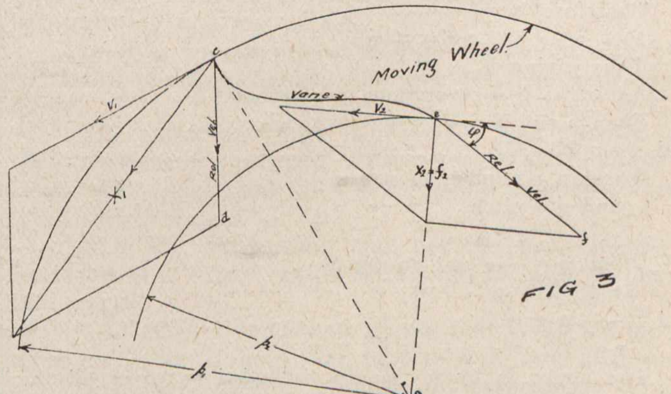
Since Ω = augmented velocity of wheel,

$$\text{therefore, } \Omega = \frac{V_1}{p_1} = \frac{V_2}{p_2}.$$

$$\text{Therefore, } V_2 = \frac{p_2}{p_1}.\; V_1 - 0.6\; V_1 \text{ say.}$$

Thus p_1, p_2 and V_2 are obtained.

X_1 is obtained from the equation $\frac{Q}{A_1} = X_1$.



Where $A_1 = 2\,\pi\,p_1\;b_1 - n\,b_1\,t = b_1\;(2\,\pi\,p_1 - n\,t)$,
and n = number of vanes (previously selected),
t = thickness of vanes: ¼-in. to ⅜-in. for steel and ½-in. when cast.

And since (see Fig. 2) $\frac{\mu_1}{X_1} = \cos\alpha$,