$$f_2 = w_2 \tan \alpha = (w_2 - u_2) \tan \beta.$$
$${}_2v_r = \sqrt{v_1^2 + u_2^2 - 2\, v_1 \,.\, u_2 \cos \alpha}$$
$$v_3 = \sqrt{{}_3v_r^2 + u_3^2 - 2_3\, v_r \,.\, u_3 \cos \gamma.}$$

But for the effect of skin friction and eddy formation in the vanes the relative velocities at entrance and exit would be the same if a given particle of water entered and left the wheel at the same radius. In an axial flow wheel this is approximately true, but not in a radial flow wheel. In the latter case the relative velocity of the points at which a particle leaves and enters is $u_3 - u_2$, and the component of this in the direction of the discharging stream is $(u_2 - u_3) \cos \gamma$.[1] It follows that, neglecting friction, the relative velocity at discharge is given by

$${}_3v_r = {}_2v_r + (u_3 - u_2) \cos \gamma.$$

If friction be taken into account

$${}_3v_r = k \left\{ {}_2v_r + (u_3 - u_2) \cos \gamma \right\},$$

where k apparently has a value of from ·90 to ·95 in a well-designed wheel.

The initial moment of momentum of the water about the axis of the wheel per lb. $= \dfrac{v_1 \cos \alpha}{g} \,.\, r_2$

[1] If different portions of the surface with which a particle comes in contact have different velocities, as in the case of a radial flow turbine, the relative velocity is not constant. It may be determined graphically, since it will be the resultant of the relative velocity at inlet, and of the component in the direction of the vane at the required point, of the relative velocity of the vane at that point and at inlet. Thus, if in Fig. 211,

$$\left\{ \begin{array}{l} n\,a = \text{relative velocity at inlet} \\ a\,b = \text{velocity of vane at inlet} \\ c\,d = \text{velocity of vane at outlet} \\ \widehat{m\,c\,p} = \gamma. \end{array} \right.$$

Then $d\,e$ = relative velocity of vane at outlet and at inlet, and $e\,f$, drawn parallel to $c\,m$, represents the component of this in the direction of the vane at outlet. If then $c\,k = n\,a$, and if $c\,k$ be produced to m where $k\,m = e\,f$, the relative velocity at outlet is represented by $c\,m$. Where, in the case of a Girard turbine, the ratio of outer and inner radii = 1·25, with a value of $\gamma = 21°$, the actual relative velocity at outlet is approximately 1·23 times that at inlet. Frictional resistance will, however, reduce this by some unknown amount, and will probably bring the ratio down to about 1·10. In any case, the effect on the value of γ for maximum efficiency will be slight, the effect being to reduce this value, and this should be taken into account in arranging the design.

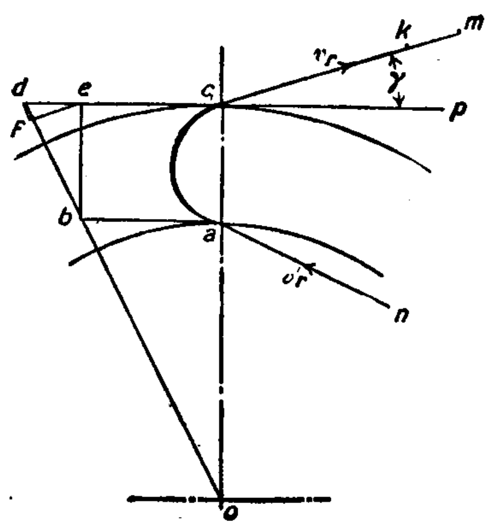

FIG. 211.