tain brake lining, one can soon correlate maximum permissible f with the duty imposed and, other factors remaining the same, this is almost independent of the type of brake used. For example, with modern friction materials $f \sim 2.4$ seems acceptable for light duty; shoe factor has almost nothing to do with it. At the design stage, the latter serves merely the purpose of evaluating the actuating load.

Finally, it has to be emphasized that the foregoing does not represent all the data necessary for brake design, but only the first few steps.

ACKNOWLEDGMENT

The author wishes to acknowledge his indebtedness to the directors of the Lockheed Hydraulic Brake Co. Ltd., Leamington Spa, for their farsighted views on research, to which this paper owes its origin ultimately.

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Discussion

B. W. SHAFFER.[3] The author is to be congratulated for applying some simple concepts of mechanics to the analysis of the brake shoe in order to help advance our knowledge of both the fixed-anchor and Huck-shoe brakes. The concept of fade sensitivity, which he introduced, is certainly one which should receive additional attention.

It seems to the writer that the ideas expressed so simply in the geometric construction of Fig. 10 also can be expressed in equation form without too much difficulty. The resulting expressions, which may be somewhat cumbersome except for special situations, would be of interest to the analyst who is looking for interrelationships between the various parameters that arise in the problem. Has the author made any attempts in this direction?

Even though the author did not elaborate on the applicability of his method of analysis to the Girling sliding shoe shown in Fig. 3, it is obvious that the method does apply and that the reaction at the abutment is normal to the surface at the point of contact whenever the coefficient of friction is small enough to be neglected. Has the author, in his experience with the problem, found friction at the surface in question to be a significant factor?

M. F. SPOTTS.[4] The author is to be commended for making available the general solution to the problem of the rigid shoe brake. As he points out, a graphical solution for actuating force W and shoe reaction S is sufficiently accurate under most conditions. Ease of obtaining such results permits the designer to give more attention to the important questions of fade and over-all performance of the brake.

Consideration might be given to the special case where the LMP coincides with the bisector of the lining arc which gives a symmetrical distribution for lining pressure. Maximum pressure then occurs on the v-axis. Direction β_1, Fig. 15, as well as magnitude, of actuating force W must be found for each value of the coefficient of friction μ. As before, direction γ of shoe reaction S is assumed to be specified.

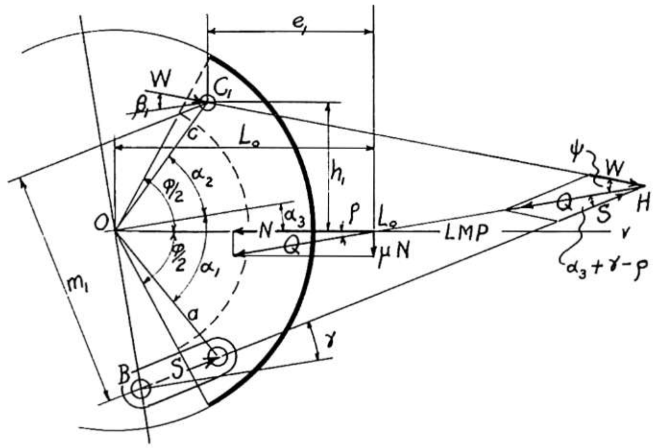

FIG. 15

Angle θ and N_w are zero so that

$$N = N_v = -{}^1/_2 p_0 bR(\varphi + \sin\varphi)$$

Force Q, the resultant of N and μN, is inclined at angle $\rho = \tan^{-1}\mu$ to the v-axis. Intersection of this line with the line of action of S locates point H and permits a force polygon to be drawn for determination of the values of W and S and inclination β_1 of force W.

Sometimes the directions for Q and S are very nearly the same in which case better accuracy can be had from algebraic equations. Force S is obtained from a moment equation about C_1 as a center

$$Sm_1 = Nh_1 + \mu Ne_1$$

where

$$m_1 = a\sin(\alpha_1 + \gamma) + c\sin(\alpha_2 - \gamma)$$

$$h_1 = c\sin(\alpha_2 + \alpha_3)$$

$$e_1 = L_0 - c\cos(\alpha_2 + \alpha_3)$$

Force W can be had by application of the cosine theorem to the force polygon

$$W^2 = S^2 + Q^2 - 2SQ\cos(\alpha_3 + \gamma - \rho)$$

Angle ψ is obtained by application of the sine theorem

$$\sin\psi = \frac{S}{W}\sin(\alpha_3 + \gamma - \rho)$$

Then

$$\beta_1 = \alpha_3 + \psi - \rho$$

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Author's Closure

The author is indebted to Dr. Shaffer and to Dr. Spotts for their kind words and constructive comments.

Referring to Dr. Shaffer's remarks, there is no difficulty in expressing analytically the geometrical construction in Fig. 10. Unless, however, $\theta = 0$, the ensuing expressions seem almost prohibitively cumbersome for the general case; see also (6). Fortunately, as Dr. Spotts intimated, all floating shoes are so designed that at the nominal value of μ the excentricity θ is either zero, or amounts to a few degrees only. It is then permissible to approximate the CP circle with another one that osculates at L_0 and is concentric with the drum. With this simplification (to second order of small quantities) the author found it possible to condense all basic properties of a shoe brake into a single and comparatively simple equation. The relevant matter will shortly appear in an ASME paper entitled: "Some Basic Properties of Shoe Brakes."

Dr. Shaffer is quite correct in assuming that with the sliding shoe brakes, as in Fig. 3, the anchor reaction is perpendicular to the abutment. Friction at the abutment seems to be annulled by vibrations of the brake shoe. Perhaps the main factor is the as yet inevitable drum excentricity or ovality in the order of 0.005 in. This, combined with the stick-slip nature of lining friction, imparts to the shoe enough oscillatory movement to obviate any directional effect the friction may have at the abutment.

Dr. Spotts sensed that the $\theta = 0$ constitutes a rather important special case. Also, for certain one-way clutches or like, a near-selflocking or selflocking may be of interest. In any event, if the actuating force W and anchor reaction S are nearly but not quite parallel, point H in Fig. 15 tends to approach infinity. The graphical construction outlined in Fig. 10 is then no longer quite simple and the analytical procedure proposed by Dr. Spotts seems preferable.

Otherwise, accuracy of the graphical method is more than adequate, such errors as there are, not being due to the method, but to the basic assumptions. Notably, one is never quite sure of the pressure pattern or of the friction in advance. As yet, both are just guesstimated.