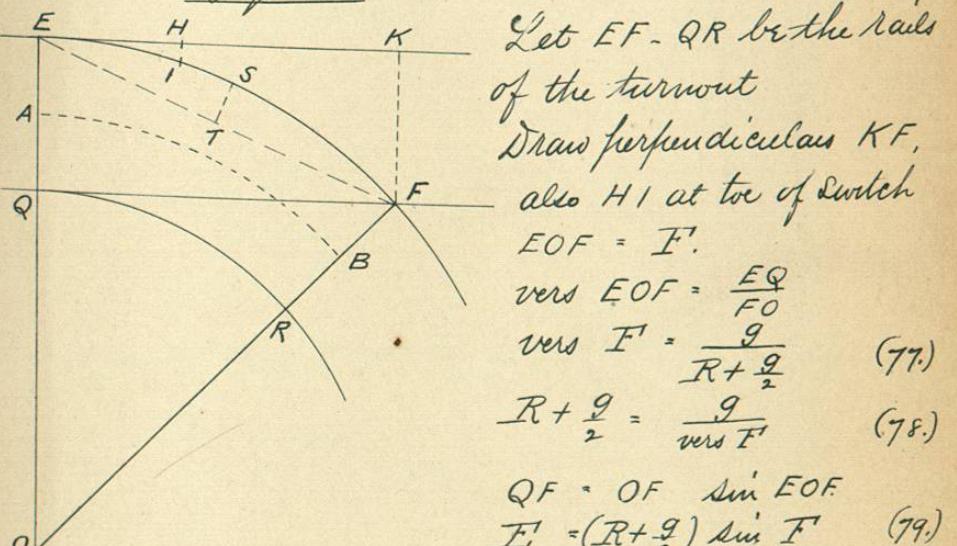


that only two be used, and that all turnout curves be arranged to use one or the other of these two frogs. (For double turnouts with point switches a third number may be necessary for a crotch frog.) In this case we should assume n (αF) as the value for one of the two "standard frogs".

On main line it is now customary to use a "split switch" or "point switch", the description and discussion of which will follow the discussion of the stub switch.

Problem Given gauge of track = g , frog angle = F , and throw of switch = t .
Required $R - t$ and $QF = F'$.



Let $EF - QR$ be the rails
of the turnout.
Draw perpendicular KF ,
also HI at toe of switch
 $EOF = F'$.

$$\text{vers } EOF = \frac{EQ}{FO}$$

$$\text{vers } F' = \frac{g}{R + \frac{g}{2}} \quad (77)$$

$$R + \frac{g}{2} = \frac{g}{\text{vers } F'} \quad (78)$$

$$QF = OF \sin EOF$$

$$F' = (R + \frac{g}{2}) \sin F' \quad (79)$$

$$\text{by (26.) } t = \frac{v^2}{2R} \text{ (approx)}$$

$$t = \sqrt{2R} \text{ (approx)} \quad (80)$$

Problem Given g-t-n.
Required R-E-T.

In the figure preceding, connect EF . Then $EFQ = FEK = \frac{1}{2}F$.

In the figure preceding, connect EF . Then $EFQ = FEK = \frac{1}{2} F$.

$$QF = EQ \cdot \cot EFQ$$

$$E = g \cot \frac{1}{2} F.$$

$$E = 2nq$$

$$FQ^2 = FO^2 - QO^2$$

$$E'^2 = \left(R + \frac{q}{2}\right)^2 - \left(R - \frac{q}{2}\right)^2$$

$$E' = \left(R + \frac{g}{2} + R - \frac{g}{2} \right) \left(R + g - R + g \right)$$

$$E^2 = 2R \times g$$

$$R = \frac{E'^2}{2g} = \frac{4g^2 n^2}{2g}$$

$$R = 2n^2q$$

$$T^2 = E'^2 \frac{t}{g}$$

$$= 4 \pi g^2 \frac{t}{a} = 4 \pi g t$$

$$T = 2\pi n \sqrt{g/t}$$

(81.)

(82)

(F.3.)

(84.)

Problem Given g
Required the middle ordinate st

$$m = \frac{c^2}{FR}$$

^{8R}
EQ is middle ordinate for chord 2FQ
^{EF}

$\bar{E}P$ (alpha)

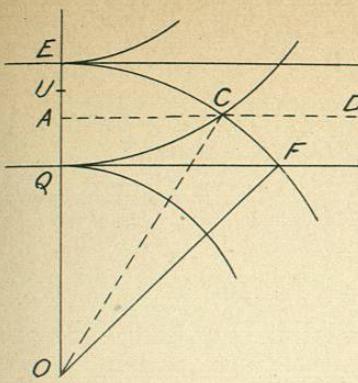
$$ST: FK = EF^2 : (2FQ)^2$$

$$ST = \frac{E/K}{t}$$

$$ST = \frac{9}{4}$$

(85.)

This is true evidently whatever the degree of curve.



Problem Given $g - R$
Required, the angle of
 croch frog = C
 The frog angle at $C = 2AOC$
 vers $AOC = \frac{EA}{OC}$
 vers $\frac{1}{2} C = \frac{\frac{1}{2}g}{R + \frac{g}{2}}$ (86.)

Problem Given the number of crossing frog = n_f
Required the number of croch frog = n_c

$$AO = R = 2n_f^2 g$$

If we consider AD to represent a rail and n_q
 the frog proper for the crossing of QC and AD

$$\text{Then } VO = 2n_q^2 \frac{g}{2}$$

But the angle between EC and QC = twice the
 angle between QC and AD

$$\text{Then } VO = 2(2n_c)^2 \frac{g}{2} \text{ (approx.)}$$

$$R = 2(2n_c)^2 \frac{g}{2} \text{ (approx.)}$$

$$2n_f^2 g = 2(2n_c)^2 \frac{g}{2} \text{ (approx.)}$$

$$n_f^2 = (2n_c)^2 \text{ (approx.)}$$

$$n_c = 0.7071 n_f \text{ (approx.)} \quad (87.)$$

Problem Given main track of radius R_m :
 also E' , g and n

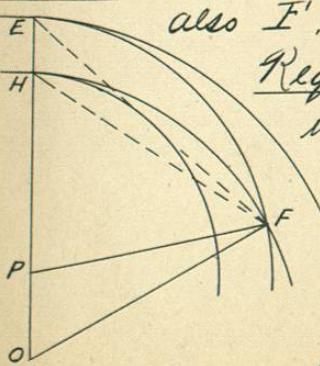
Required radius R_t of a turnout
 inside of main track; also E .

Let EB be the outer rail of
 main track.

EF the outer rail of turnout.

Join EF

Let $\angle EOF = \theta$; $\angle PFO = I'$



In the triangle EOF

$$EO = R_m + \frac{g}{2}$$

$$FO = R_m - \frac{g}{2}$$

$$EFO - FEO = EFO - EFP = F'$$

$$EFO + FEO = 180^\circ - O$$

$$\text{Then } \tan \frac{1}{2}(EFO + FEO) : \tan \frac{1}{2}(EFO - FEO) = EO + FO : EO - FO$$

$$\cot \frac{1}{2}O : \tan \frac{1}{2}F' = 2R_m : g$$

$$\tan \frac{1}{2}O : \cot \frac{1}{2}F' = g : 2R_m$$

$$\tan \frac{1}{2}O = \frac{g}{2R_m} \cot \frac{1}{2}F' = \frac{g^2 n}{2R_m}$$

$$\tan \frac{1}{2}O = \frac{gn}{R_m} \quad (88.)$$

Similarly $FPH = F + O$

Join HF and in triangle HPF, $\tan \frac{1}{2}(F + O) = \frac{gn}{R_t}$

$$R_t = \frac{gn}{\tan \frac{1}{2}(F+O)} \quad (89.)$$

$$\text{chord } HF = E = 2(R_m - \frac{g}{2}) \sin \frac{1}{2}O \quad (90.)$$

Approximate Formula

Let $R - D$ = Radius and degree of a turnout curve from a straight line to correspond to the given value of F or n .

$R_m - D_m$ = Radius and degree of main track.

$R_t - D_t$ = Radius and degree of turnout curve.

$$\text{Then from (88.) (89.) } R_m = \frac{ng}{\tan \frac{1}{2}O} ; R_t = \frac{ng}{\tan \frac{1}{2}(O+F)}$$

$$\text{also (83.) } R = 2n^2 g = ng \times 2n = \frac{ng}{\tan \frac{1}{2}F'}$$

$$\sin \frac{1}{2}D_m = \frac{50}{R_m} = \frac{50 \tan \frac{1}{2}O}{ng}$$

$$\sin \frac{1}{2}D_t = \frac{50}{R_t} = \frac{50 \tan \frac{1}{2}(O+F')}{ng}$$

$$\sin \frac{1}{2}D = \frac{50}{R} = \frac{50 \tan \frac{1}{2}F'}{ng}$$

$$\sin \frac{1}{2} D_m : \sin \frac{1}{2} D_t : \sin \frac{1}{2} D : \tan \frac{1}{2} O : \tan \frac{1}{2} (O+F) : \tan \frac{1}{2} F$$

$$D_m : D_t : D = O : O+F : F \text{ (approx.)}$$

$$D_m + D : D_t = O+F : O+F \text{ (approx.)}$$

$$D_t = D_m + D \text{ (approx.)} \quad (91.)$$

$$\text{Again (90.) } HF = E_i = 2(R_m - \frac{g}{2}) \sin \frac{1}{2} O$$

$$(82.) \quad E_i = 2ng \text{ (tangent from straight track)}$$

$$88. \quad = 2R_m \tan \frac{1}{2} O$$

But $\frac{g}{2}$ is small compared with R_m and may be neglected.
and for small angles $\sin \frac{1}{2} O = \tan \frac{1}{2} O$ (approx.)

$$HF = E_i = 2R_m \tan \frac{1}{2} O \text{ (approx.)}$$

$$E_i = 2gn \text{ (approx.)} \quad (92.)$$

The above formula and (91.) while approximate are the formulas in general use.

It is difficult in practical track work to secure results more precise than would be obtained by the use of these approximate formulas.

Example. Given a 3° curve on main line
and a no 9 frog

Required the degree of turnout curve
to the inside of the curve

Table XI Searles' shows for a no 9 frog, the
degree of curve = $7^{\circ} 31' 04''$; this is ordinarily
taken - $7^{\circ} 30'$ = D

$$\text{degree of main line} = 3^{\circ} 00' = D_m$$

$$\text{degree of turnout} = \frac{10^{\circ} 30'}{10^{\circ} 30'} = D_t = D + B_m$$

$$\text{By precise formula } 10^{\circ} 34' = D_t$$

Problem Given main track of radius R_m
also $F - g - n$.

Required radius R_t of a turnout curve
outside of main track.

- L I. When the center of turnout curve
lies outside of main track
B Let EB be the outer rail of main
track.
and HF the outer rail of turnout.

Join HF . Let $HOF = O$
Then $PFL = F$

$$\text{In the triangle } HOF \quad FO = R_m + \frac{g}{2}$$

$$HO = R_m - \frac{g}{2}$$

$$\text{Also } FHO + HFO = 180^\circ - O$$

$$FHO - HFO = 180^\circ - PHF - (180^\circ - PHF - F)$$

$$= F$$

$$\text{Then } \tan \frac{1}{2}(FHO + HFO) : \tan \frac{1}{2}(FHO - HFO) = FO : HO ; FO - HO$$

$$\cot \frac{1}{2} O : \tan \frac{1}{2} F = 2R_m : g$$

$$\tan \frac{1}{2} O = \frac{gn}{R_m} \quad (93.)$$

$$\text{Similarly } OPF = F - O$$

$$\text{Join } EF \text{ and in triangle } EPF, \tan \frac{1}{2}(F - O) = \frac{gn}{R_t}$$

$$R_t = \frac{gn}{\tan \frac{1}{2}(F - O)} \quad (94.)$$

$$\text{Chord } EF = E' = 2(R_m + \frac{g}{2}) \sin \frac{1}{2} O \quad (95.)$$

Approximate Formulas.

$$D_t = D - D_m \quad (\text{approx.}) \quad (96.)$$

$$E' = 2ng \quad (\text{approx.})$$

II. When the center of turnout curve lies on the inside of main track

By a process entirely similar it may be shown
that $\tan \frac{1}{2} O = \frac{g n}{R_m}$

$$R_t = \frac{g n}{\tan \frac{1}{2}(O - I')}$$
 (98.)

$$I' = 2(R_m + \frac{g}{2}) \sin \frac{1}{2} O$$
 (99.)

Approximate Formulas.

$$D_t = D_m - D \quad (\text{approx.})$$
 (100.)

$$I' = 2ng \quad (\text{approx.})$$

Split Switch.

In turnouts from main line, it is customary now to use the split switch. In this switch the outer rail of the main line and the inner rail of the turnout track are continuous.

The switch rails are steel rails, each planed down at one end to a wedge point, so that it may be caused to lie close against the track rail and so turn the wheel in the direction intended. An angle is made between the main track and the switch rail. The fixed end of the switch rail is placed at a point corresponding to the "head-block" of the stub switch, and the distance between rails at this point is generally made the same as

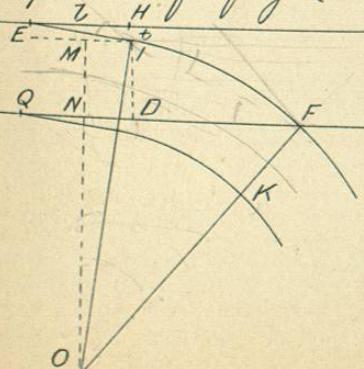
the "throw" of the stub switch (from 5" to 6").
The switch rail is often made 15 feet in length.
The "switch angle" is determined by the length
of switch rail and this distance between rails
(gauge to gauge) and which we may call t .

With the split switch a common practice
is to calculate the turnout for a stub switch;
the fixed end of the split switch is then
placed at the point where the movable end
of a stub switch would be placed, and the
point of the switch wherever this will bring
it. This gives results approximately correct, and
sufficiently good to satisfy the requirements
of many roads.

Some prefer a more exact solution.

Problem. Given, in a turnout, the gauge of
track g , length of switch rail t , the
distance between rails t , and frog angle F .

Required the radius of turnout track
and distance from movable end of rail to
point of frog (or the "lead".)



Let EHF and QKF be the rails
of the turnout.

Draw MI parallel and
 OM perpendicular to QF

Let s = switch angle.

$$t = HI$$

$$l = EA$$

$$\text{Then } \sin s = \frac{t}{l}$$

$$MN = MO - NO \\ g-t = (R + \frac{g}{2}) \cos S - (R + \frac{g}{2}) \cos F'$$

$$R + \frac{g}{2} = \frac{g-t}{\cos S - \cos F'} \quad (101.)$$

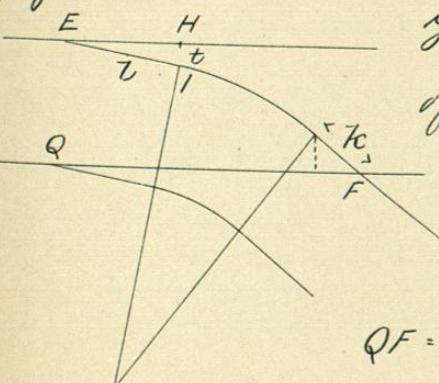
$$QF = QD + DF \\ = \ell \cos S + \frac{10}{\tan IFD}$$

$$QF = \ell + \frac{g-t}{\tan \frac{1}{2}(F+S)} \quad (102.)$$

Some prefer even greater precision and give weight to the fact that the frog is straight, not curved.

Problem. Given, in a turnout, the gauge of track g ; length of switch rail ℓ ; distance between rails t ; length of frog, end to point K ; and the frog angle F .

Required. the radius of turnout curve, and the distance from movable end of rail to point of frog.



Then following the methods of the preceding problem

$$\sin S = \frac{t}{\ell}$$

$$R + \frac{g}{2} = \frac{g-t - R \sin F}{\cos S - \cos F} \quad (103.)$$

$$QF = \ell + \frac{g-t - R \sin F}{\tan \frac{1}{2}(F+S)} \quad (\text{approx.}) \quad (104.)$$

+ Kest