Fig. 9.17. Kinematic layout for 14 speed gear box

DESIGN OF GEAR BOX

9.12. DESIGN PROCEDURE FOR GEAR BOX

Ψ → Psi

1. *Selection of spindle speeds :*

✓ Determine the progression ratio (ϕ) using the relation

$$\phi^{n-1} = \frac{N_{max}}{N_{min}}$$

✓ For the calculated ϕ, select the standard spindle speeds using the series of preferred numbers, from Table 9.2. (7.20) D.D

2. *Construct the ray diagram,* as discussed earlier.

3. *Construct the kinematic arrangement* for the given gear box, as discussed earlier.

4. *Calculation of number of teeth on all gears :* Calculate the number of teeth of all the gears engaged in all stages of the gear box.

5. *Select the suitable material,* consulting Tables 9.4 and 9.5.

6. *Calculation of module :*

✓ Calculate the torque for the gear which has the lowest speed using the relation,

$$T = \frac{P \times 60}{2 \pi N} \quad \text{... (9.}$$

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✓ Calculate the tangential force on the gear in terms of module using the relation (refer Fig.9.18),

$$F_t = \frac{T}{r} = \frac{2T}{z \times m} \quad \ldots (9.5)$$

$$\left[\because T = F_t \times r \text{ and } r = \frac{z \cdot m}{2} \right]$$

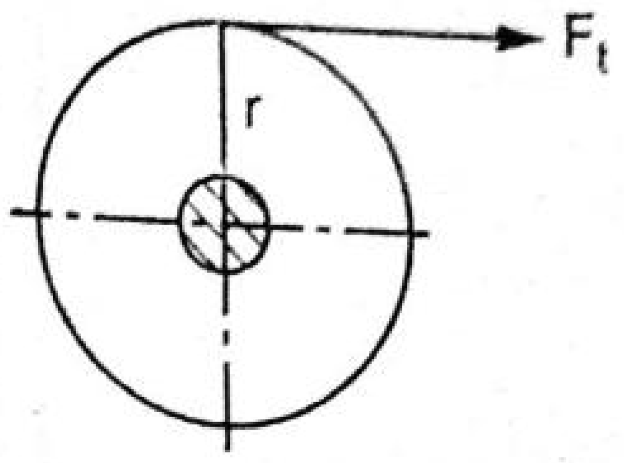

Fig. 9.18.

✓ Now calculate the module using the relation

$$m = \sqrt{F_t / \psi_m \times M} \quad \ldots (9.6)$$

where ψ_m = Ratio between the face width and module $= \frac{b}{m} = 10$,

M = Material constant, from Table 9.4.

Table 9.4. Material constant (M)

Material	Material constant (M)
C45	30
15 Ni 2 Cr 1 Mo 15	80
40 Ni 2 Cr 1 Mo 28	100

7. ***Calculation of centre distance in all stages :*** Calculate the centre distance in each stage by using the relation

$$a = \left(\frac{z_x + z_y}{2} \right) m \quad \ldots (9.7)$$

where z_x and z_y = Number of teeth on the gear pair in engagement in each stage.

8. ***Calculation of face width :*** $b = 10 \times m$ $b = \psi . m$

9. ***Calculation of distance between the bearings i.e., length of shafts :***

Calculate the distance between the bearings by using the following assumptions, (refer Fig.9.19) :

✓ Give 10 mm clearance between the gear and the bearing on both sides.

✓ Take the distance between the adjacent groups of gears as 20 mm.

✓ Take the total length for two pairs gear group as $4b$ and for three pairs gear group as $7b$, as shown in Fig.9.19.

✓ Assume the width of the bearings as 25 mm.

∴ Distance between the bearings is given by

$$L = 25 + 10 + 4b \text{ (or } 7b) + 20 + 7b \text{ (or } 4b) + 10 + 25 \quad \ldots (9.8)$$

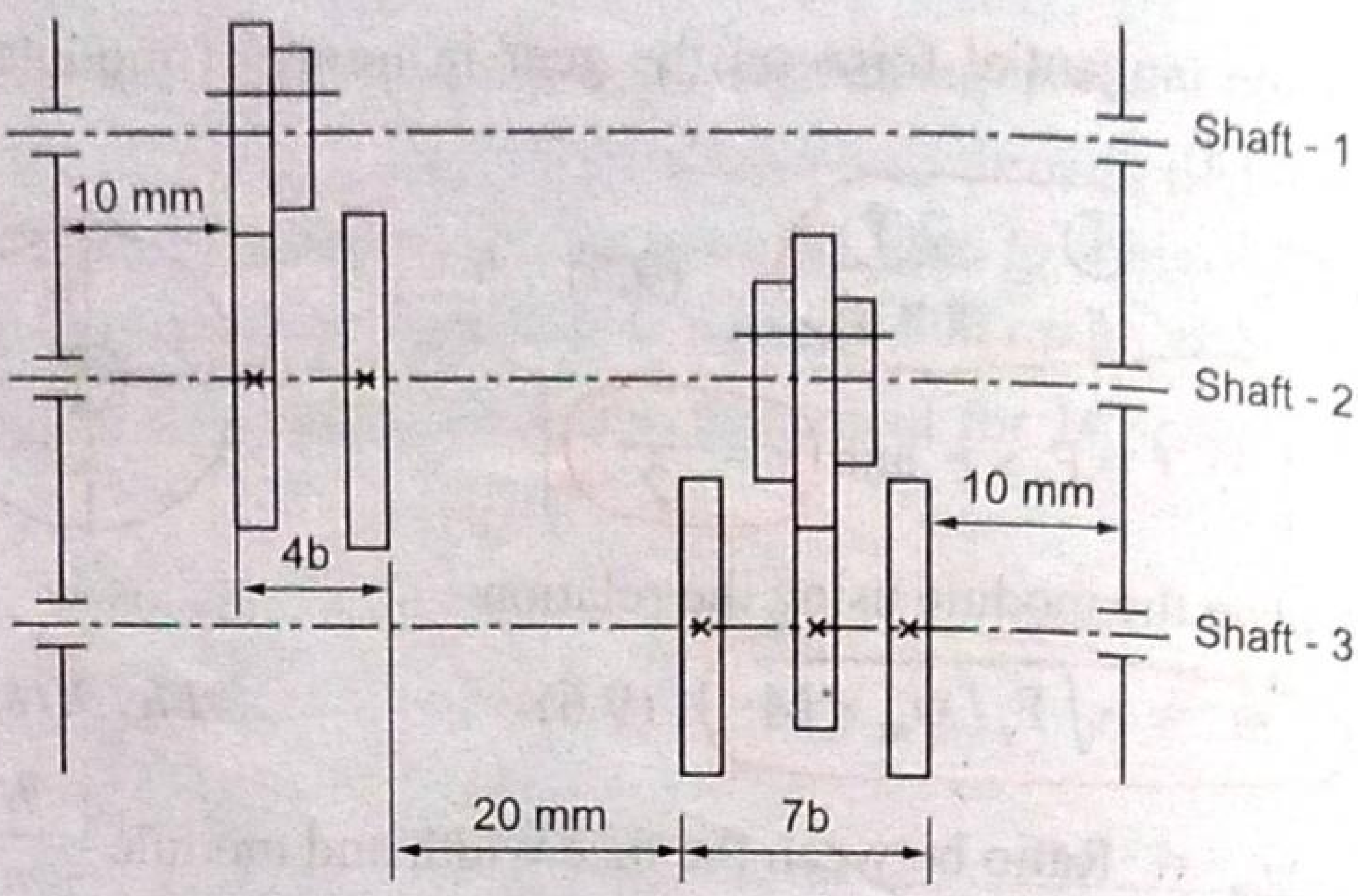

Fig. 9.19.

10. *Design of shafts :*

(i) Design of spindle i.e., output shaft : Design the output shaft for maximum bending moment by considering the shaft as simply supported on bearings (refer Fig.9.20).

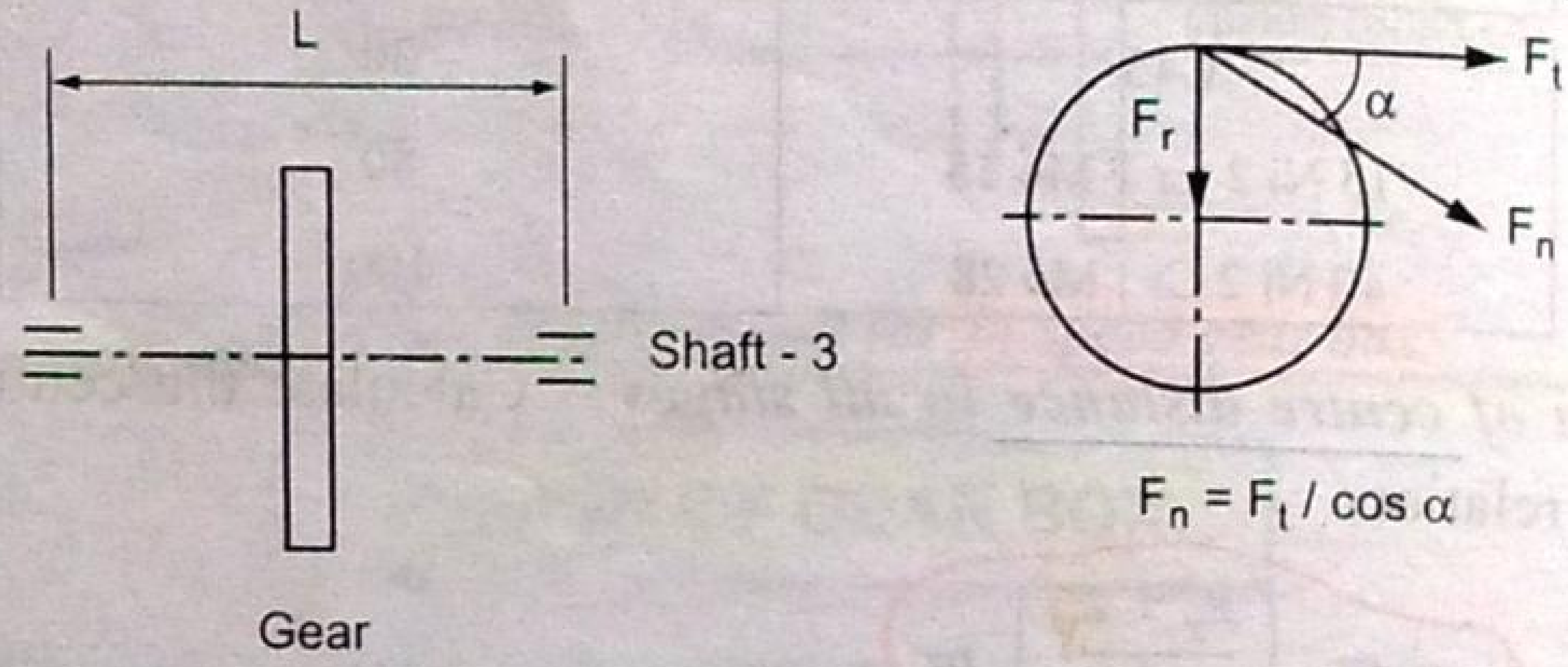

Fig. 9.20.

✓ Calculate the maximum bending moment due to normal load (F_n) using the relation

$$M = \frac{F_n \times L}{4} \quad \text{... (9.9)}$$

where F_n = Normal load on gear = $\frac{F_t}{\cos\alpha}$

✓ Calculate the equivalent torque using the relation

$$T_{eq} = \sqrt{M^2 + T^2} \quad \text{... (9.10)}$$

where T = Torque on the spindle = $\frac{P \times 60}{2\pi N_{low}}$

✓ Calculate the diameter of the spindle using the relation

$$d_s = \left[\frac{16 \times T_{eq}}{\pi[\tau]}\right]^{\frac{1}{3}} \quad \left[\because [\tau] = \frac{16\,T_{eq}}{\pi d_s^3}\right] \quad \text{... (9.11)}$$

where $[\tau]$ = Permissible shear stress, from Table 9.5.

Table 9.5. Permissible shear stress [τ], N/mm²

S.No.	Shaft material	[τ], N/mm²
1.	C14 (as supplied)	25
2.	C45 (case hardened)	30
3.	Low carbon alloy steel (case hardened)	40
4.	40 Ni 2 Cr 1 Mo 28 (hardened and tempered)	55

(ii) Design of other shafts : Determine the diameter of the input and intermediate shafts using the relation

$$T = 0.2\ d_s^3 [\tau] \quad \ldots (9.12)$$