FORCES ACTING ON TILLAGE IMPLEMENTS

BY

Shekhar kumar sahu

$$D = F_i(A + BS + CS^2)WT$$

where:

D	is	implement draft, N (lbf);
F	is	a dimensionless soil texture adjustment parameter (table1);
I	—	1 for fine, 2 for medium and 3 for coarse textured soils;
A, *B* and *C*	are	machine-specific parameters (table1);
S	is	field speed, km/h (mile/h).
W	is	machine width, m (ft) or number of rows or tools (table1);
T	is	tillage depth, cm (in.) for major tools, 1 (dimensionless) for minor tillage tools and seeding implements.

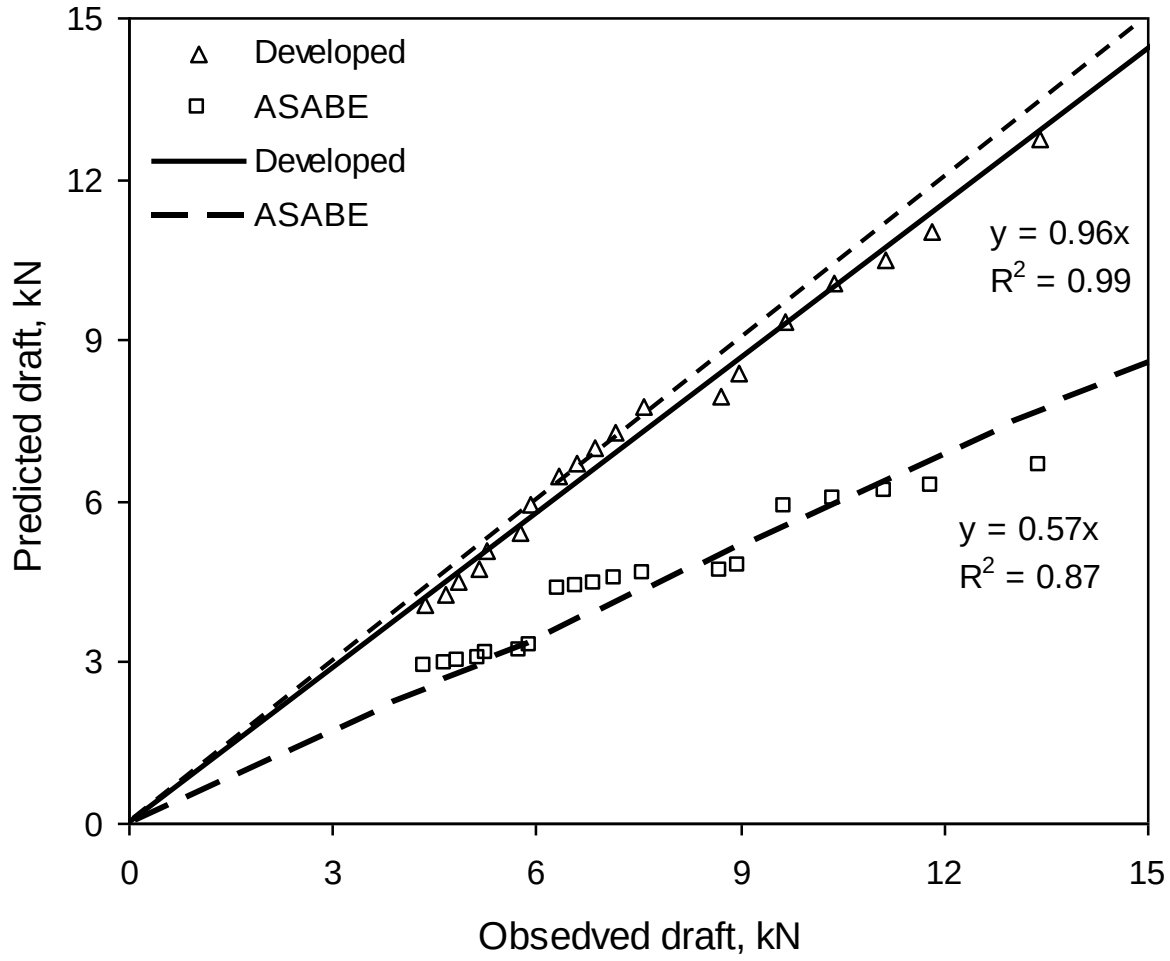


Fig. Comparison of observed and predicted draft values based on two draft equations for moldboard plough

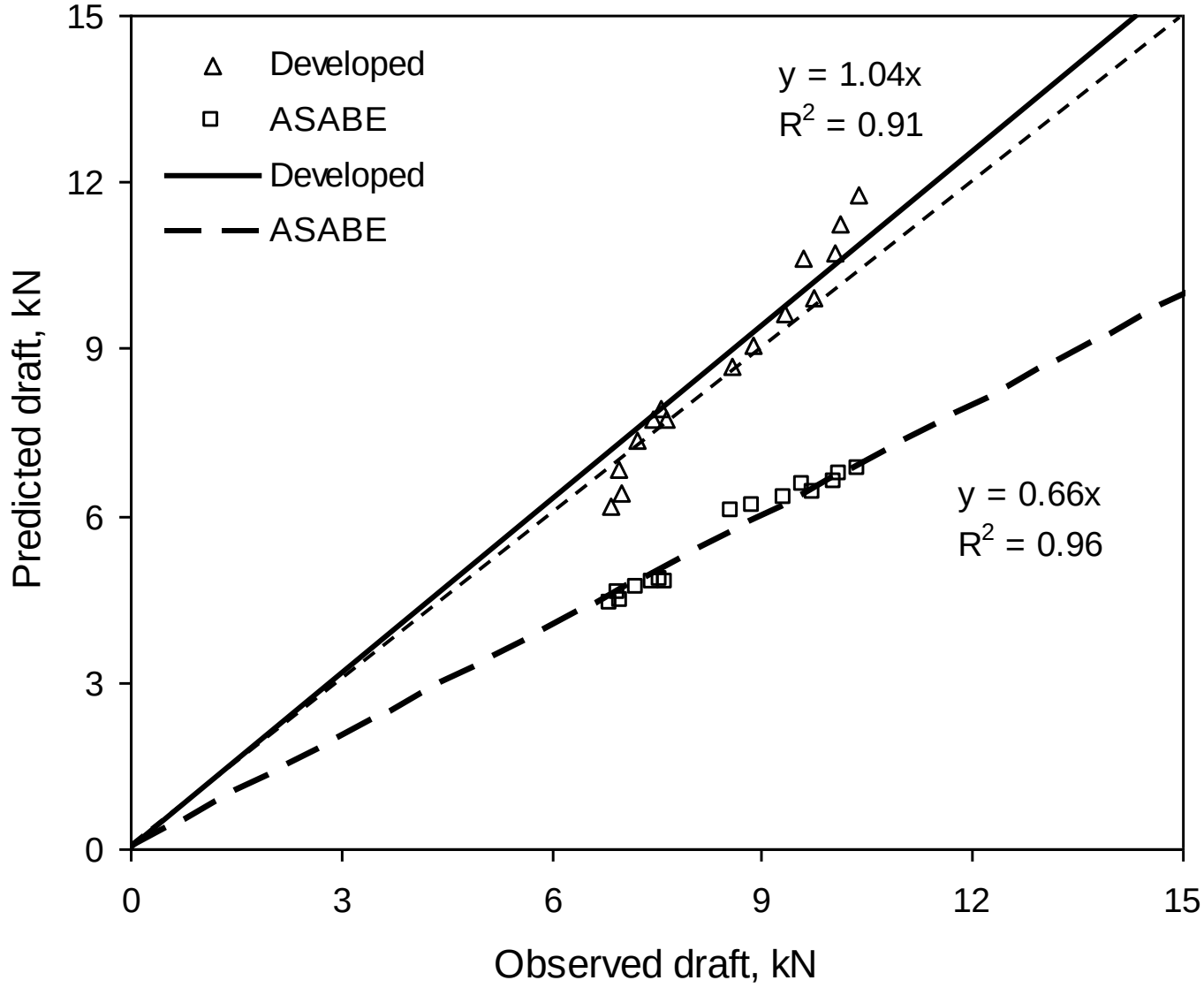


Fig. 5.17: Comparison of observed and predicted draft values based on two draft equations for cultivator

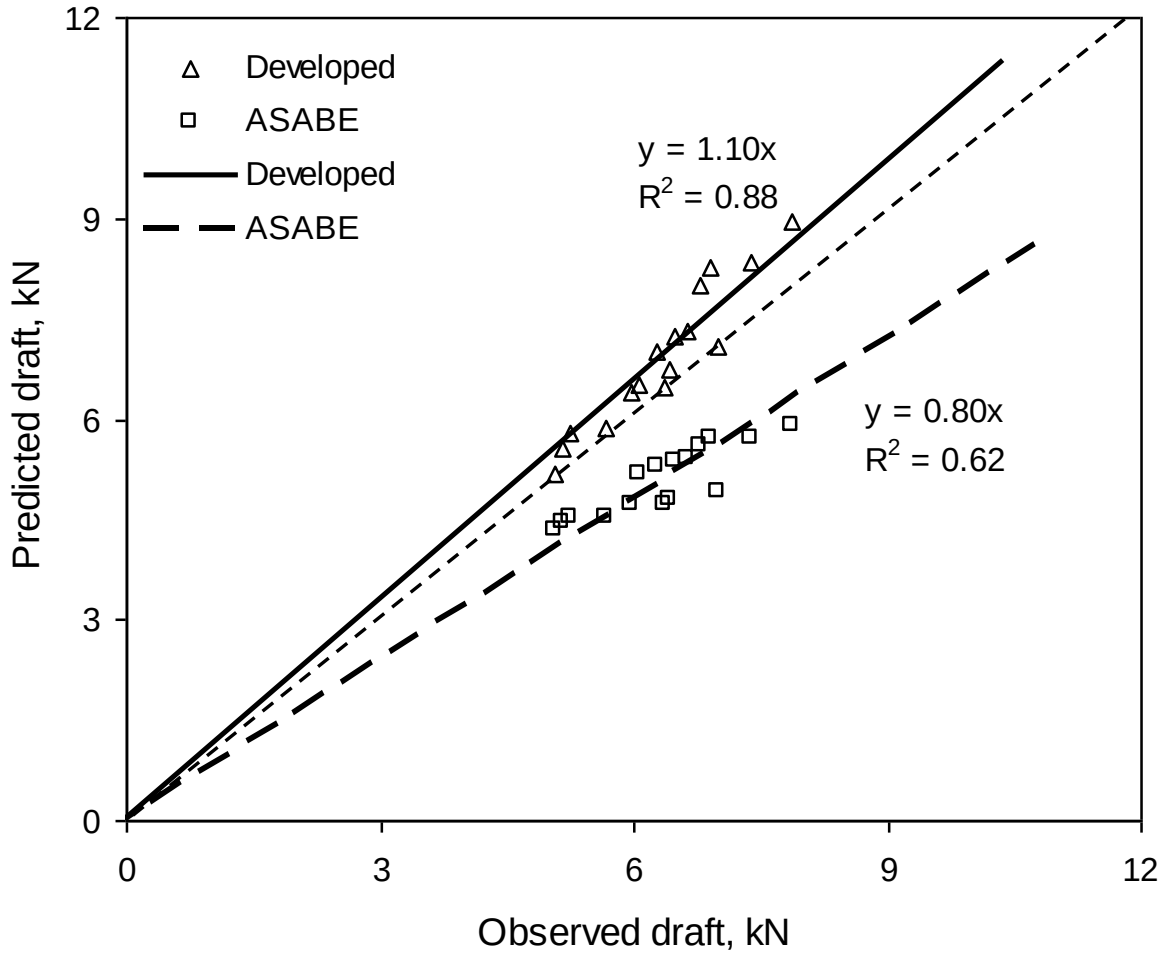


Fig. Comparison of observed and predicted draft values based on two draft equations for offset disc harrow

$$D = \{A \times CI + B \times S + C \times S^2\} W \times T$$

where D = implement draft, N

A, B and C = machine-specific parameters

A = *f* (soil strength)

B or C = *f* (speed of operation)

S = speed of operation, km/h

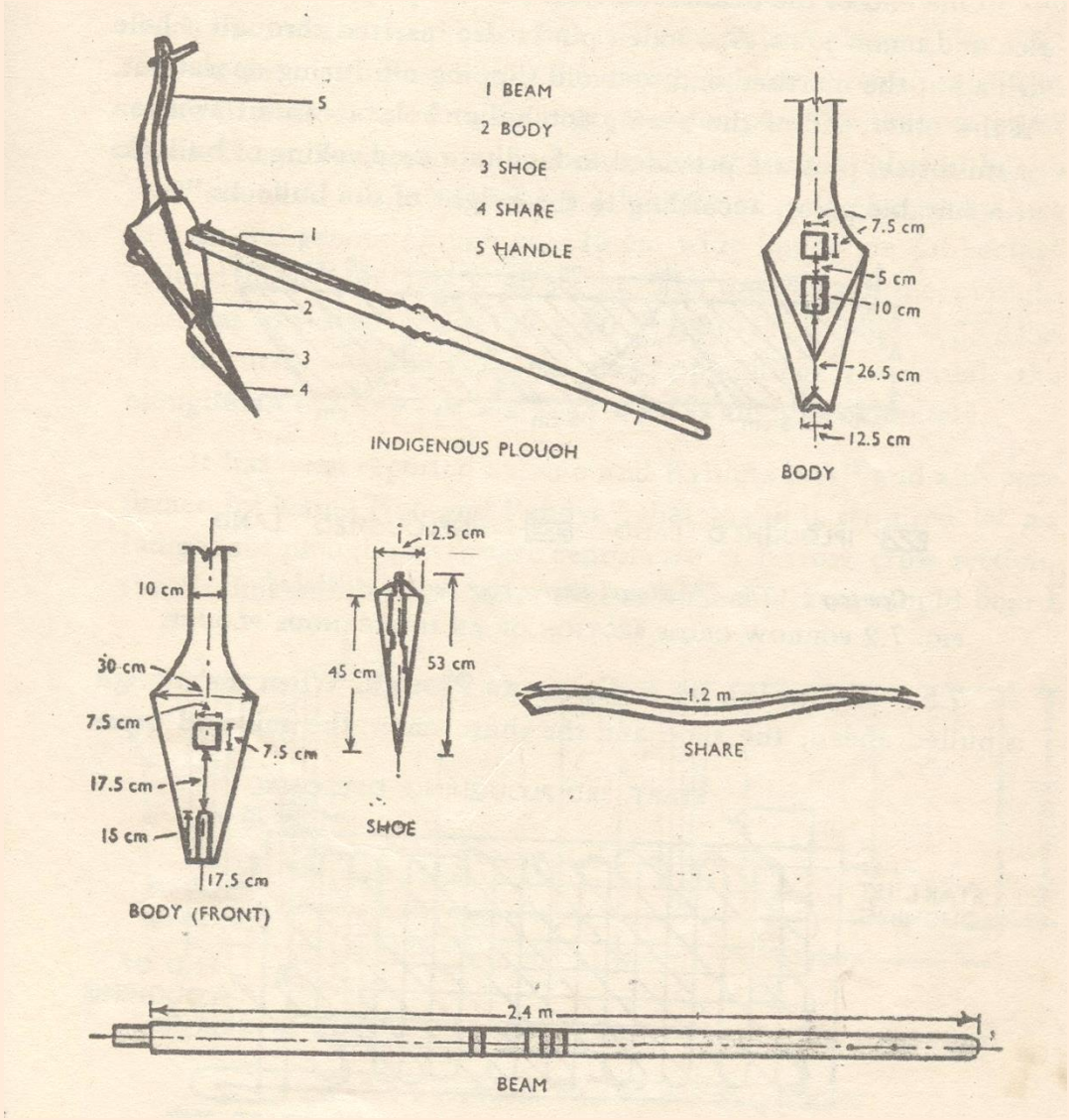
W = machine width, m or number of furrow opener or tools

T = tillage depth, cm

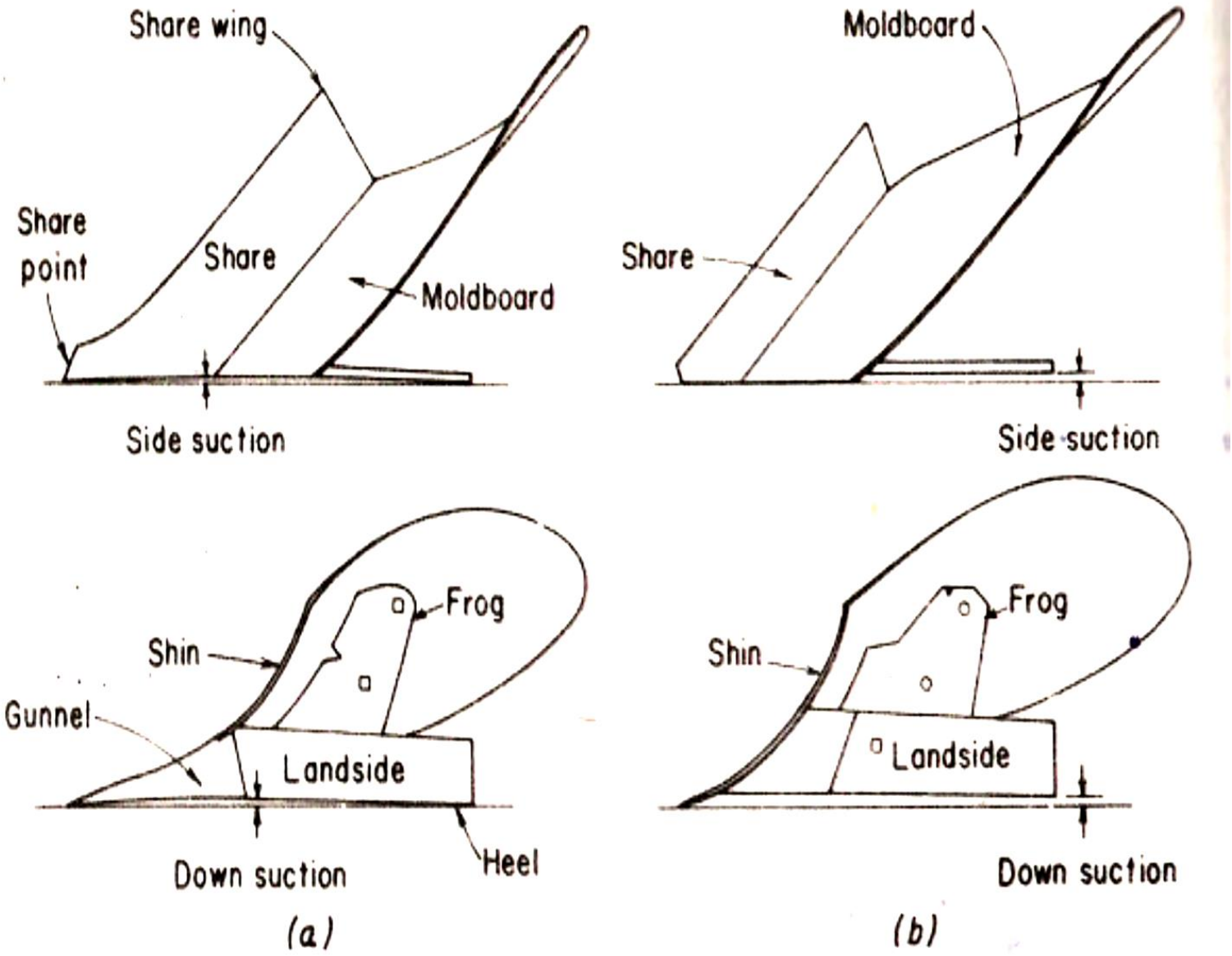
Table 1 : Results of Stepwise Regression Analysis for Draft of Tillage Implements

Tillage implement	Variable	CI×W×T	S×W×T	S^2×W×T
	Coefficient	A	B	C
Moldboard Plow	Parameter Estimate	0.42	0.00#	16.40
	Standard Error	0.01		0.88
	F Value	1128.21		343.32
Cultivator	Parameter Estimate	0.04	5.50	0.40
	Standard Error	0.001	0.66	0.13
	F Value	1466.08	68.62	9.40
Offset disc harrow	Parameter Estimate	0.32	37.96	0.00
	Standard Error	0.006	1.14	
	F Value	2661.29	1105.55	

#The coefficients are entered as zero when found statistically not significant at 5 percent level



Parts of indigenous plough



Typical moldboard plow bottoms. (a) gunnel type share (b) with throw away share with down and side suctions.

(1) Point of the share that enters first in the soil and also supports the plough bottom.

(2) Throat of the share that cuts the furrow slice from the main soil body.

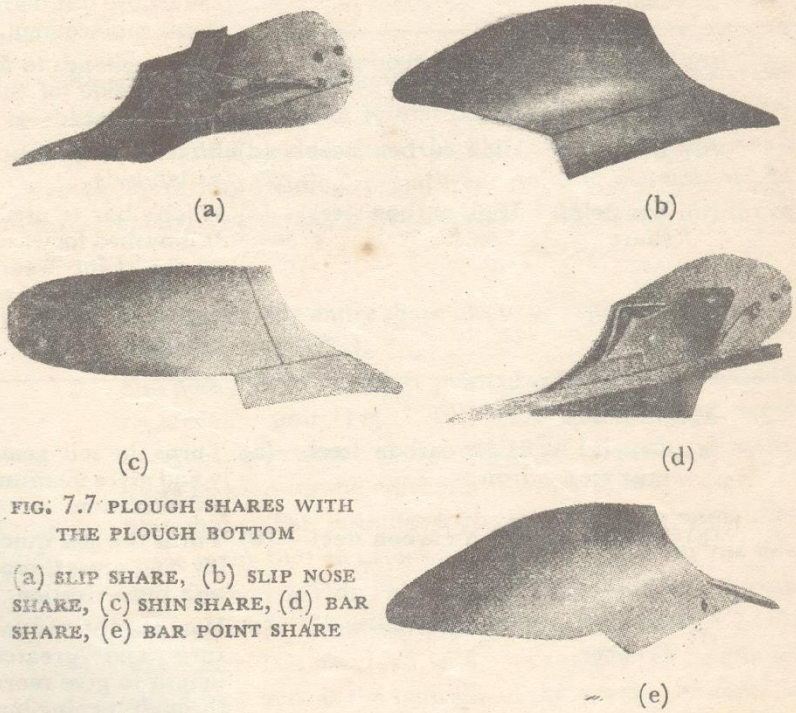


FIG. 7.7 PLOUGH SHARES WITH THE PLOUGH BOTTOM

(a) SLIP SHARE, (b) SLIP NOSE SHARE, (c) SHIN SHARE, (d) BAR SHARE, (e) BAR POINT SHARE

(3) Wing of the share that supports the plough bottom.

(4) Gunnel of the share that supports the plough bottom against the furrow wall.

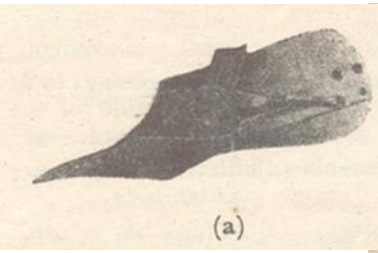
Slip share : The entire share has to be replaced after it has worn out (Fig. 7.7a).

Slip nose share : The share point of such a share is a small replaceable unit (Fig. 7.7b). Before the complete share becomes unserviceable, the point can be changed many times to keep up the efficiency of work at lower cost.

Shin share : This is similar to the slip share, the only difference being that an extension is provided to fit by the side of the mould board. This prevents the mould board from wearing along its cutting edge, called the shin (Fig. 7.5c).

Bar share : It is provided with an extension on its gunnel side which acts as the landside of the plough bottom. It does not offer any advantage over the other types (Fig. 7.7d).

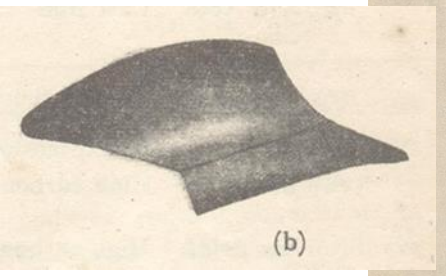
Bar point share : In addition to the main share, a steel bar, which extends as the share point, is also provided



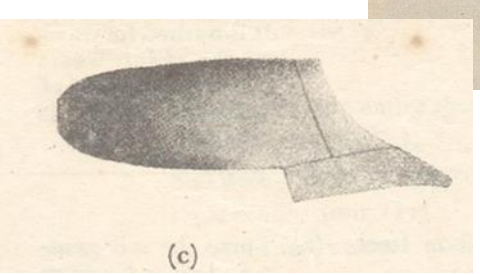
(a)

Table 7.1. Parts of Plough Bottom and Materials Used in their Construction.

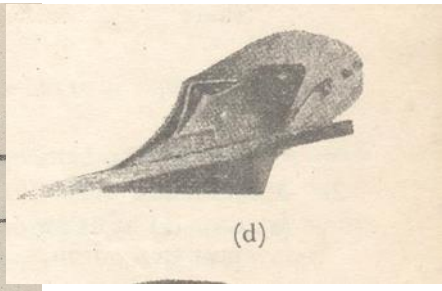
S.N.	Parts	Materials	Remarks
1.	Share		
	(a) Slip share	High carbon steel, soft center steel, cast iron	(a) Slip share is the common type of share on animal drawn and tractor drawn ploughs. Complete share is replaced when worn out.
	(b) Slip Nose share	Cast iron	(b) Only nose is replaced before full share needs replacement.
	(c) Shin share	High carbon steel	(c) Share extends to fit by the side of the mould board.
	(d) Bar share	High carbon steel	(d) Share extends to act as landside.
	(e) Bar point share	High carbon steel	(e) A long bar is used. It is pushed forward as the point wears out. Replacement of complete share is avoided.



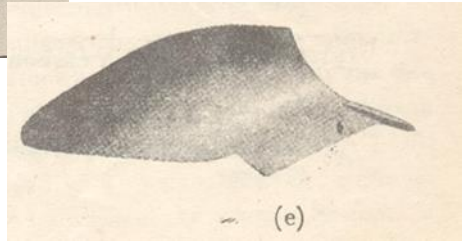
(b)



(c)



(d)



(e)

1. General purpose—It is the best for all round general farm use to give through pulverization.

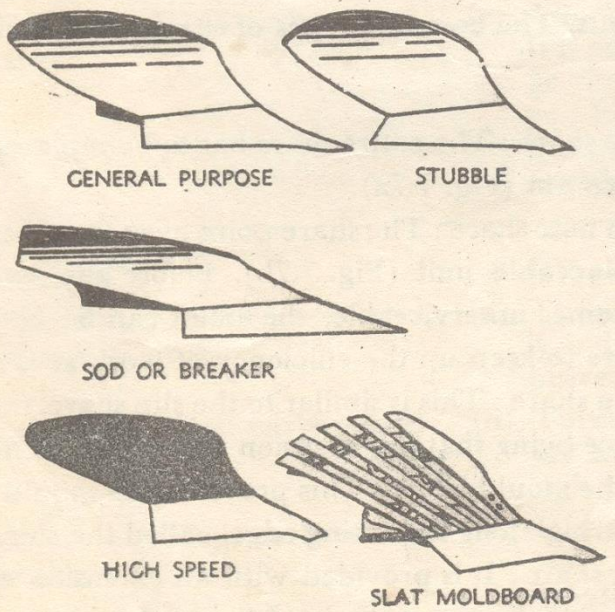


FIG. 7.8 A FEW COMMONLY USED MOULD BOARDS

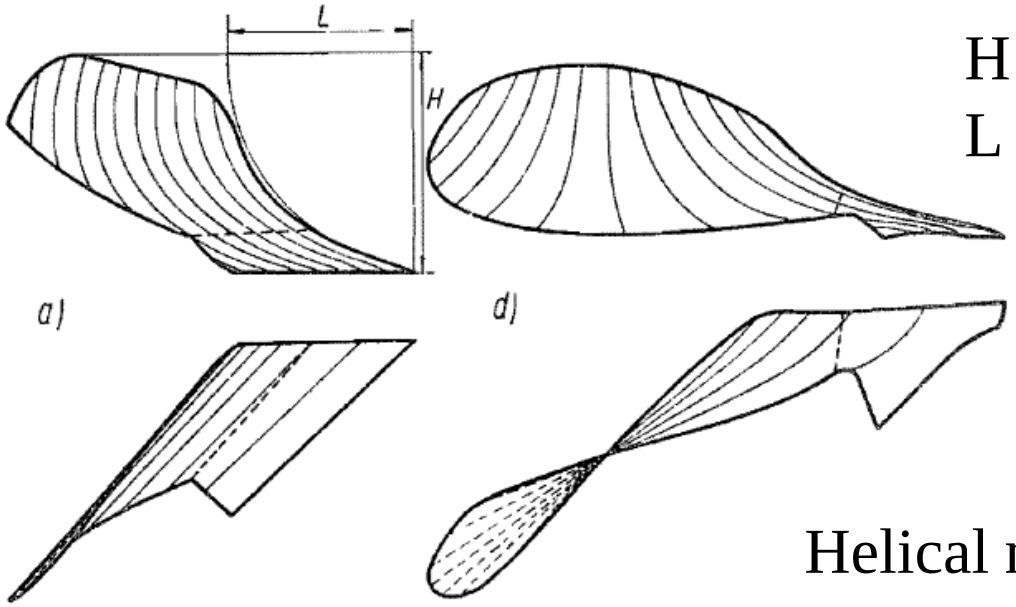
S.N.	Parts	Materials	Remarks
2.	Mould board		
	(a) General purpose	High carbon steel, iron	(a) Turns the soil gently and gives medium pulverization.
	(b) Stubble	High carbon steel	(b) Turns the soil quickly and gives thorough pulverization.
	(c) Sod or Breaker	High carbon steel	(c) Has abrupt curvature and greater length to give more through turning but less pulverization.
	(d) Slat	High carbon steel	(d) Is used in light sticky soils.
	(e) Highspeed	High carbon steel	(e) Has short and less abrupt curvature.

2. Stubble—It is adapted for ploughing an old ground where good pulverization is desired. It has relatively short and broad mould board that is curved rather abruptly near the top.
3. Sod or Breaker—The breaker bottom is used in tough sod (grass land) where it is desired to turn the furrow slice completely so that the grass may not continue to grow.
4. Slat—It is preferred for more sticky soils where it is difficult to get the mould board to scour.
5. High speed—Most of the high speed bottoms are used on tractor ploughs for general farm use.

S.N.	Parts	Materials	Remarks
3.	Landside	Soft center steel or mild steel or cast iron	Sometimes, a detachable. piece is provided at the extreme end, called the heel of the land side.
4.	Frog	Mild steel or cast iron	All the other parts are fastened to the frog.

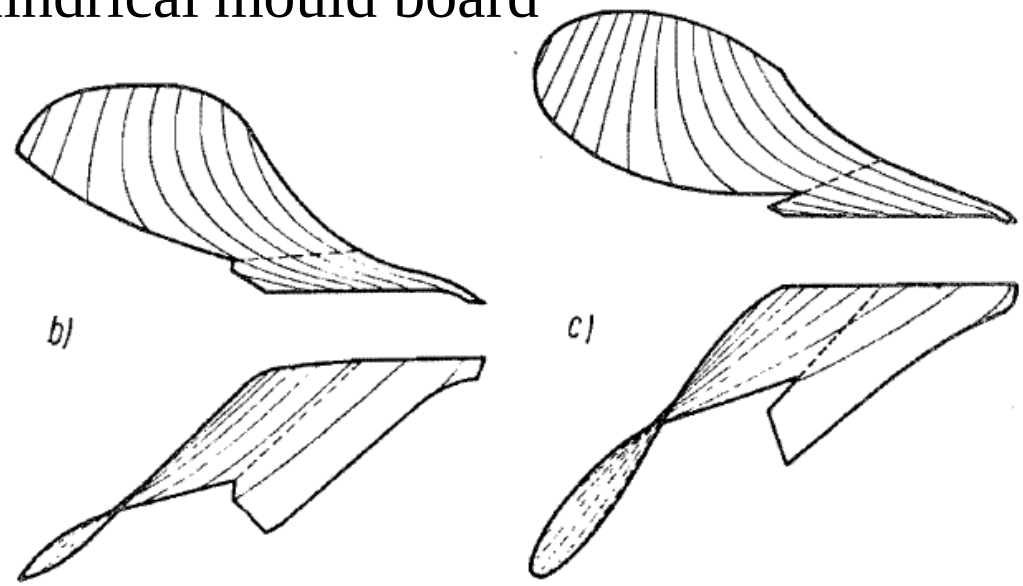
H = height of the mould board

L = Slope of the mould board



Helical mould board

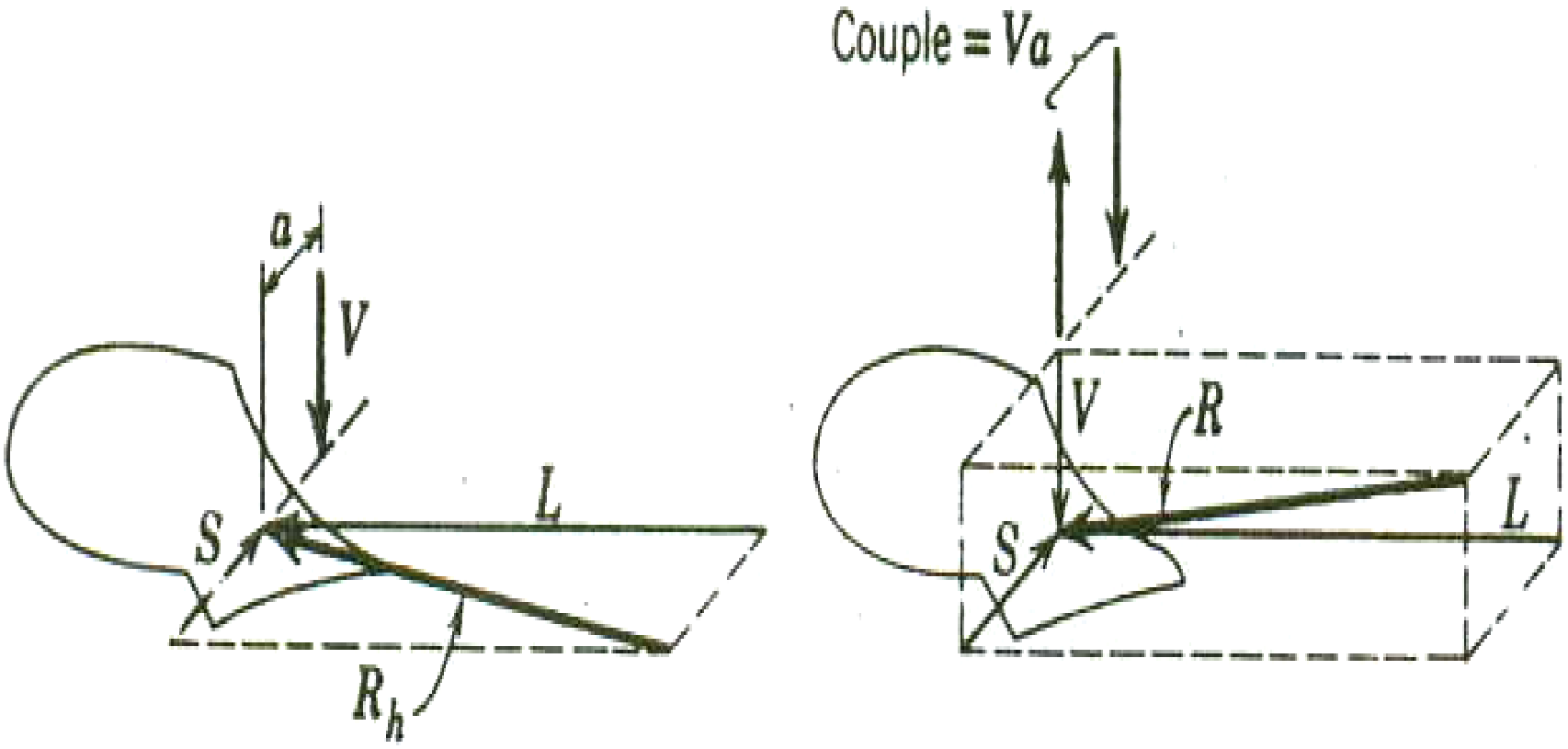
Cylindrical mould board



Semihelical mould board

Cylindroidal mould board

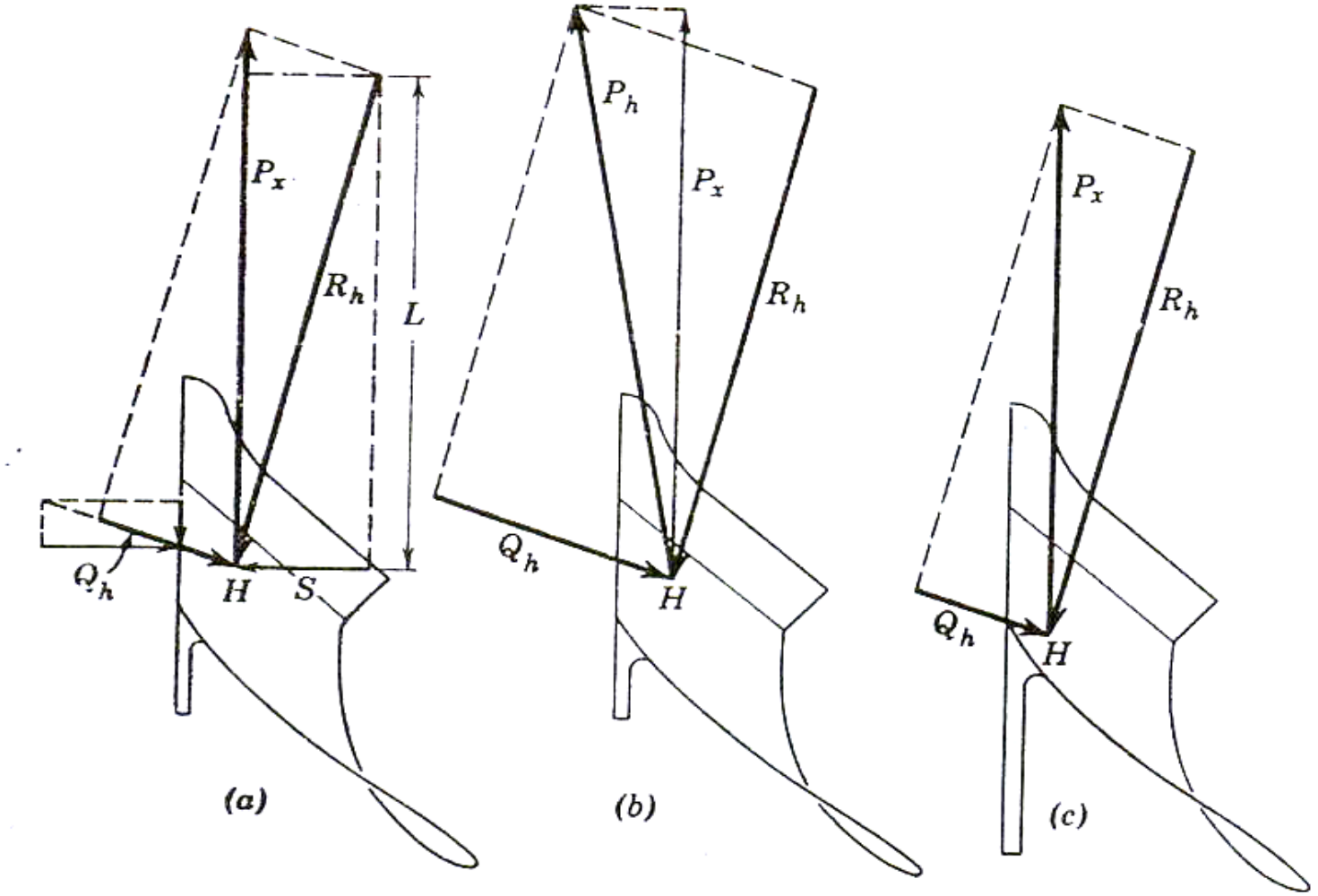
Kind of moldboard	Type od moldboard	$\frac{L}{H}$
Steep	cylindrical,,seldom cylindroidal	0.7—0.8
Standard	cylindroidal and semihelical	0.8—1.0
Inclined	cylindroidal, semihelical and helical	1.0—1.3 seldom up to 1.4



Two nonintersecting forces, R_h and V

One force R, plus a couple V_a

Fig. 1 Two ways of expressing the total soil reaction on a tillage tool.



(a) Straight pull **(b) Angled pull** **(c) long landside**

Fig. 2 Typical location of R_h and its relation to the landside force and the pull.

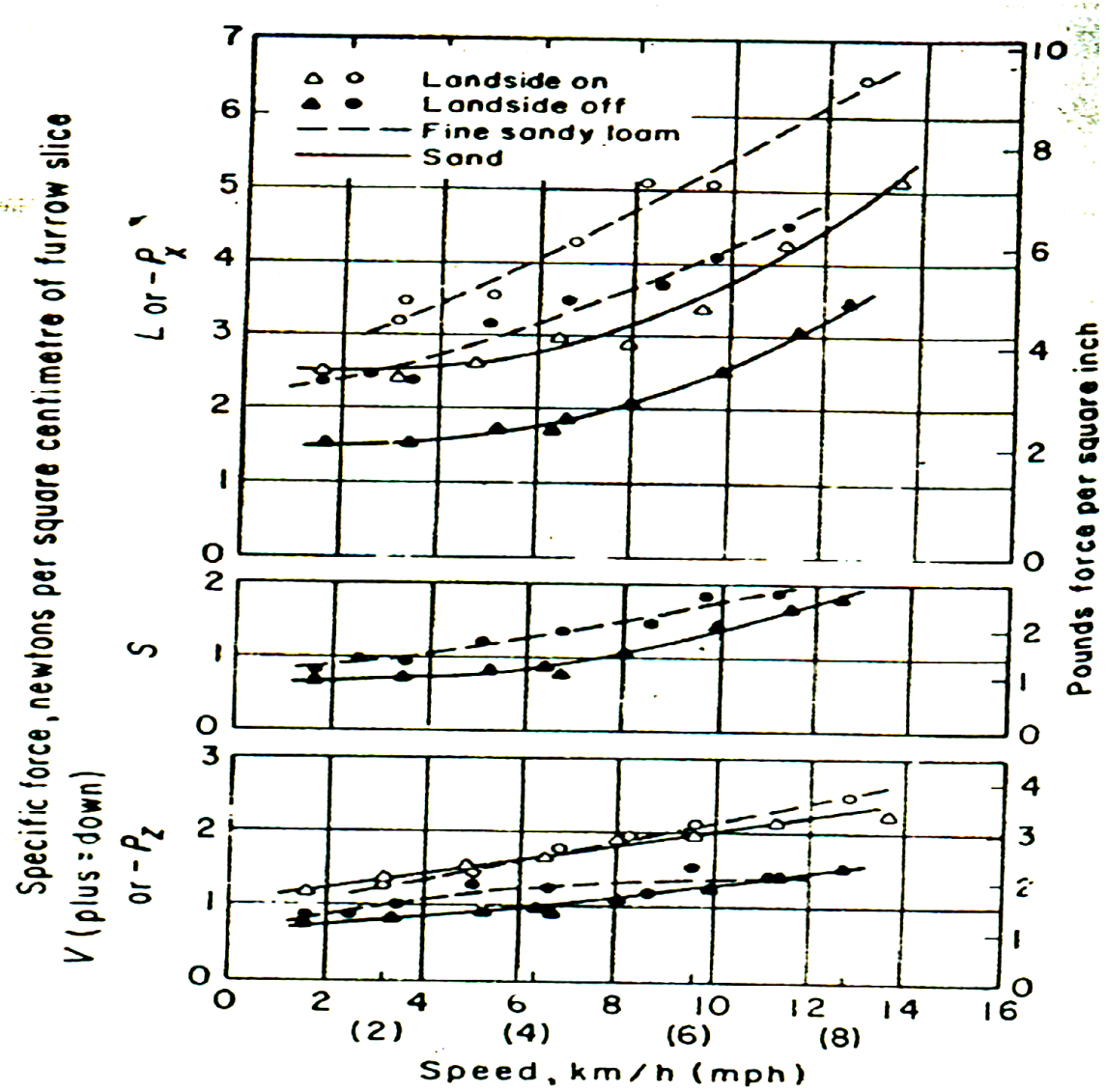
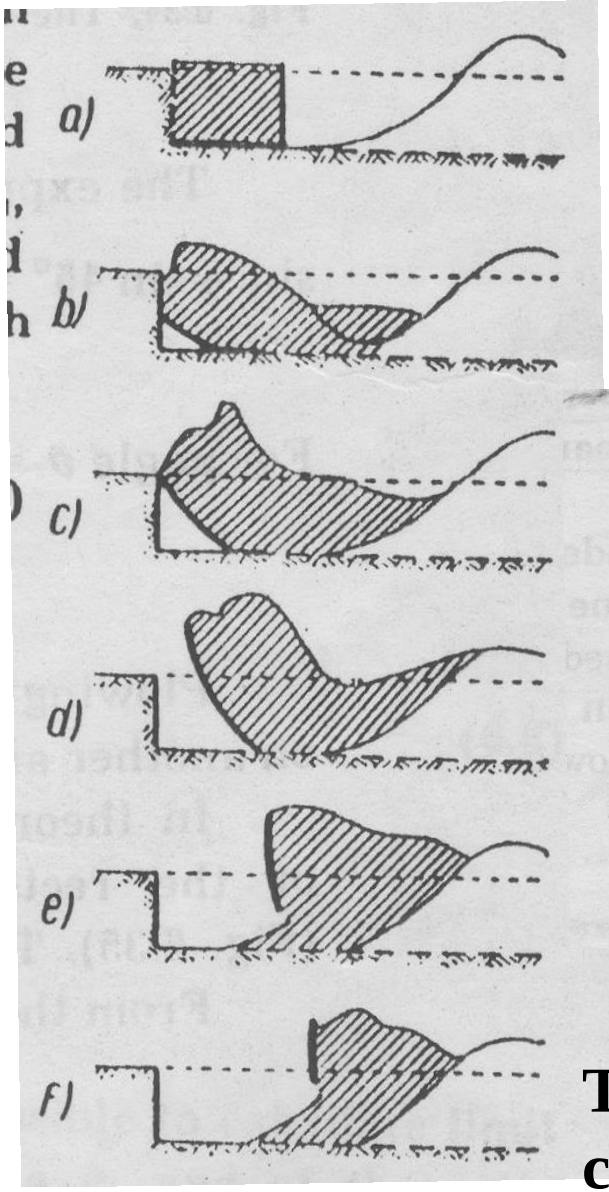


Fig. 3 Effect of speed upon L,S, and V forces for a 36-cm general purpose plow bottom tested in soil bin with and without the landside.



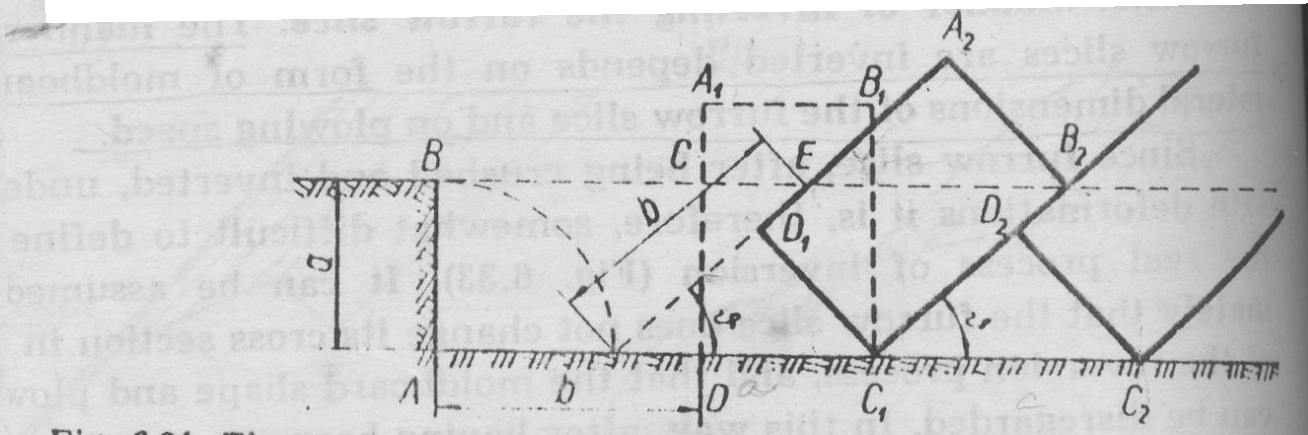


Fig. 6.34. The course of theoretical inversion of the furrow slice by the bottom.

The course of furrow slice inversion by cylindroidal mould board in medium firm soil

Table 1. Ratio of b/a for different type of tillage

Types of moldboards	Angles		
	Θ_0	α	γ
Helical, semihelical and cylindroidal for lea tillage and rapid tillage	30°—35°	12°—15°	20°—25°
Semihelical and cylindroidal moldboards for tractor plows for normal tillage	35°—45° most commonly 40°	14°—18° most commonly 16°	22°—28°
Cylindroidal and cylindrical moldboards for horse-drawn plows	40°—50° most commonly 45°	15°—20° most commonly 18°	20°—30°

The share forms a spatial wedge (Fig. 6.29) with three basic angles:

α — load angle,

γ — cutting angle,

Θ_0 — setting angle.

Between these angles there is the following relation

$$\tan\gamma = \frac{\tan\alpha}{\sin\Theta_0} \qquad (6.1)$$

From the diagram presented in Fig. 6.20 this relation can easily be formulated as follows

$$\tan\alpha = \frac{OB}{OC}$$

$$OC = \frac{OD}{\sin\Theta_0}$$

hence

$$\tan\alpha = \frac{OB}{OD}\sin\Theta_0$$

and since

$$\frac{OB}{OD} = \tan\gamma$$

then

$$\tan\alpha = \tan\gamma\sin\Theta_0$$

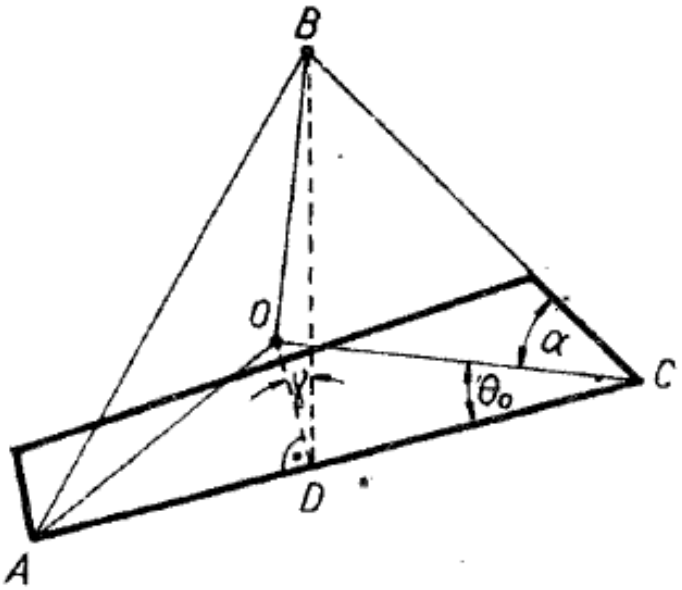


Fig. 6.29. Share as a spatial wedge.

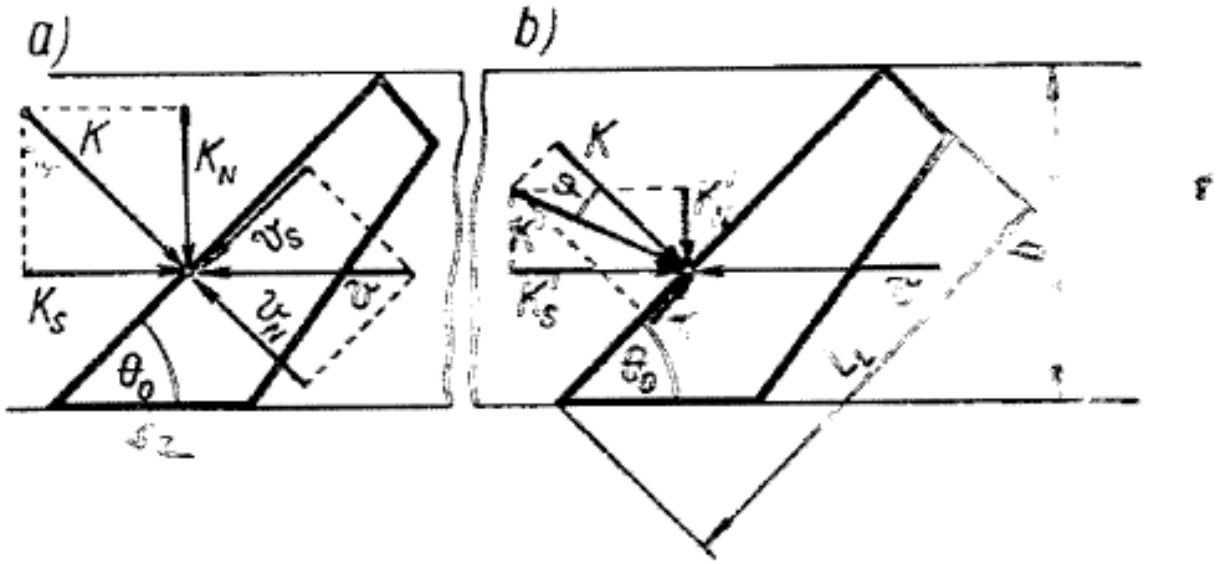
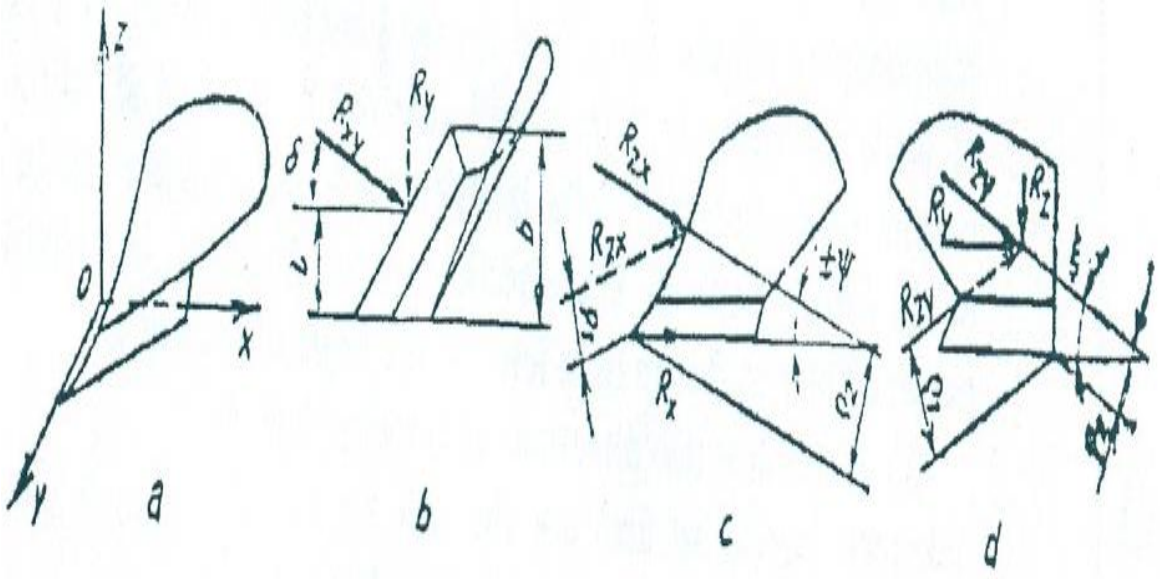


Fig. 6.30. Distribution of forces and speeds on the edge of the share.

Dimension	Maximal depth of tillage					
	15 cm	20 cm	25 cm	30 cm	35 cm	45 cm
l	400	450	500	550	500—700	500—700
S_1	115	125	135	150	150	160
S_2	100	105	115	125	125	130



Forces acting upon a plow bottom

Table 1. Ratio of b/a for different type of tillage

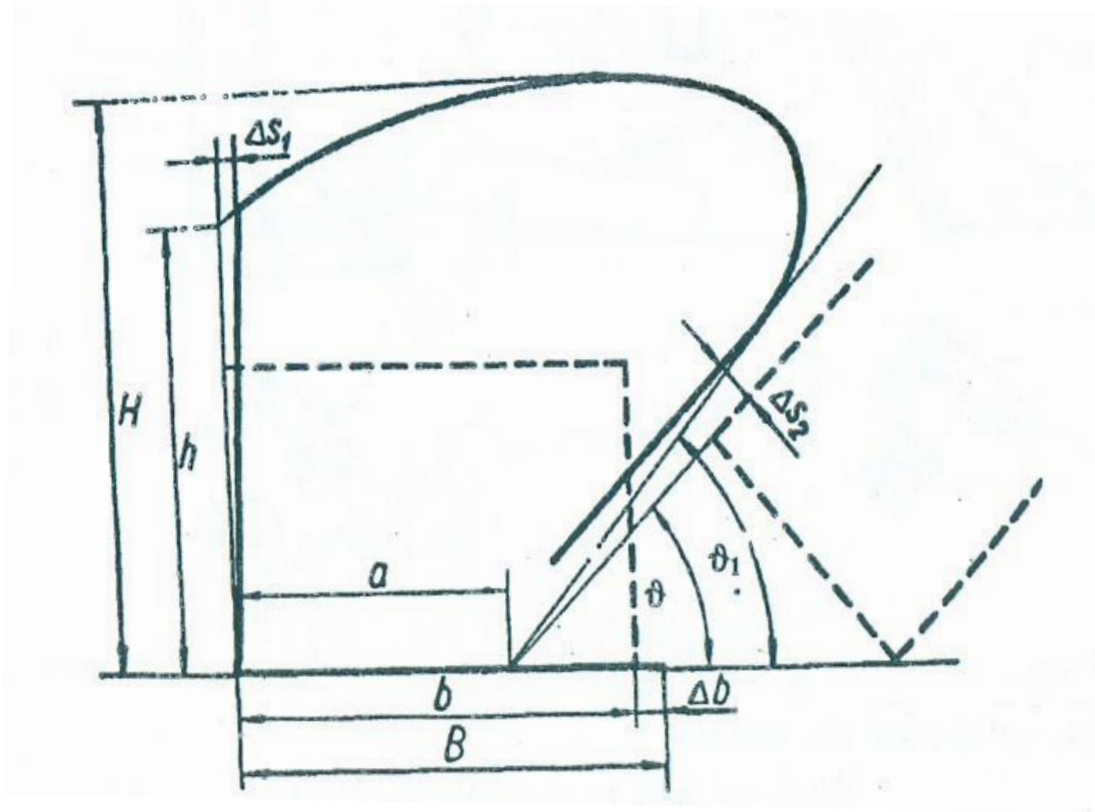
Types of mould boards	Angles, degree		
	θ_0	α	γ
Helical, semi-helical and cylindroidal for lea tillage and rapid tillage	30-35	12-15	20-25
For tractor plough for normal tillage	35-45	14-18	22-28
Cylindroidal and cylindrical mould board plough for animal drawn ploughs	40-45	15-20	20-30

Table 2. Values of different angles commonly used on different mouldboard ploughs

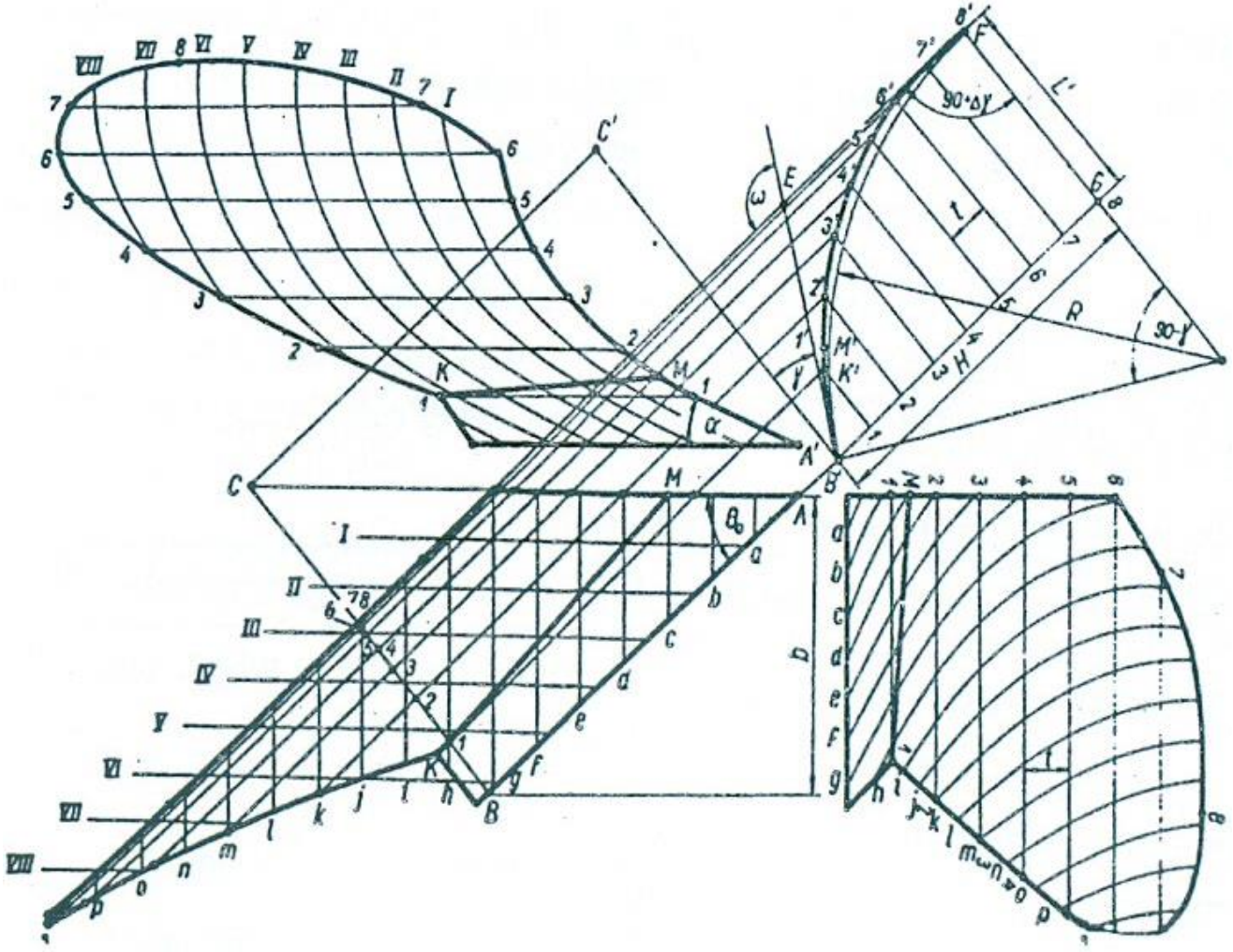
S.N.	Type of tillage	Tillage depth (a), mm	Width of the furrow slice (b), mm	b/a ratio
1.	Very deep	350-1000	400-700	0.7-1.1
2.	Deep	250-350	300-400	1.1-1.5
3.	Medium	180-240	200-350	1.3-1.8
4.	skimming	50-120	240	2.0-5.0

Values of Δb, Δh1, Δh2, Δh3, Δs1, Δs2 for different types of plough

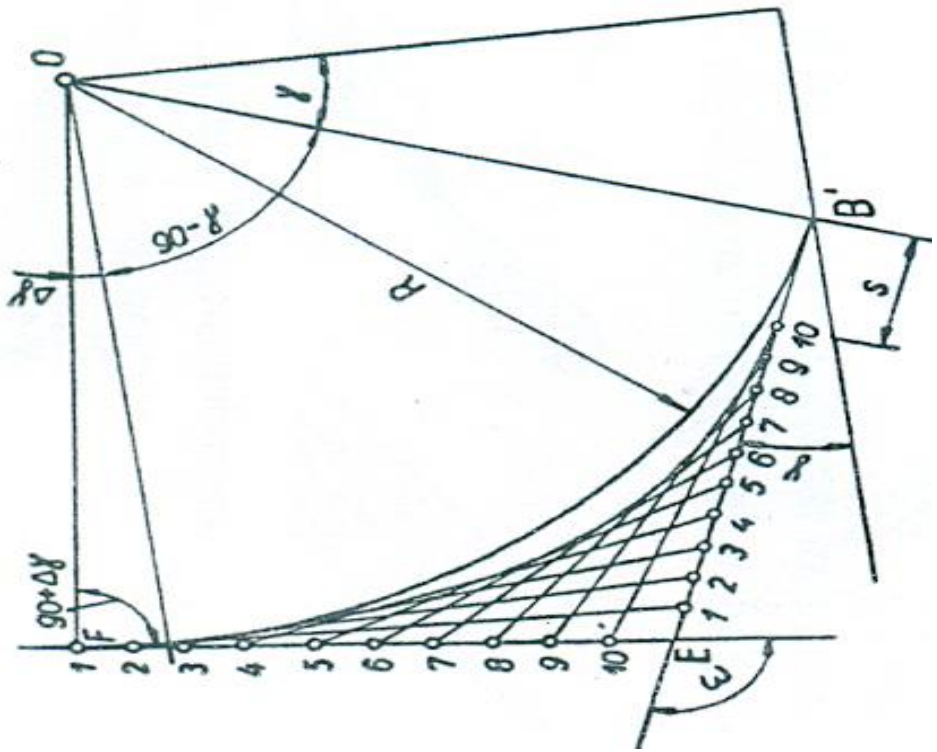
Values of Δb for different ploughs	
Standard plough	(+20)-(+40)mm
Lea Plough	(-20)-(-40)mm
Values of Δh_1 for different soils	
Medium firm and firm soil	(0)-(-20)mm
Light and sandy soil	(0)-(+20)mm
For grass lands	(-0.1b)- (-0.2b)
Values of Δh_2	
For grass land	(0)If velocity of operation v<7kmh^{-1} (+5) -(+10) mm per 1 kmh^{-1}, above v>7 kmh^{-1}
Values of Δh_3	
For general ploughs	(0)–(-30) mm
Helical and semi- helical mould board	Slightly less than the general plough
Values of Δs_1 andΔs_2	
Δs_1	(+5)-(+10) mm
Δs_2	20mm



Determination of frontal plan of a mould board



Design of a cylindrical mouldboard



Plotting of parabolas by the tangential methods