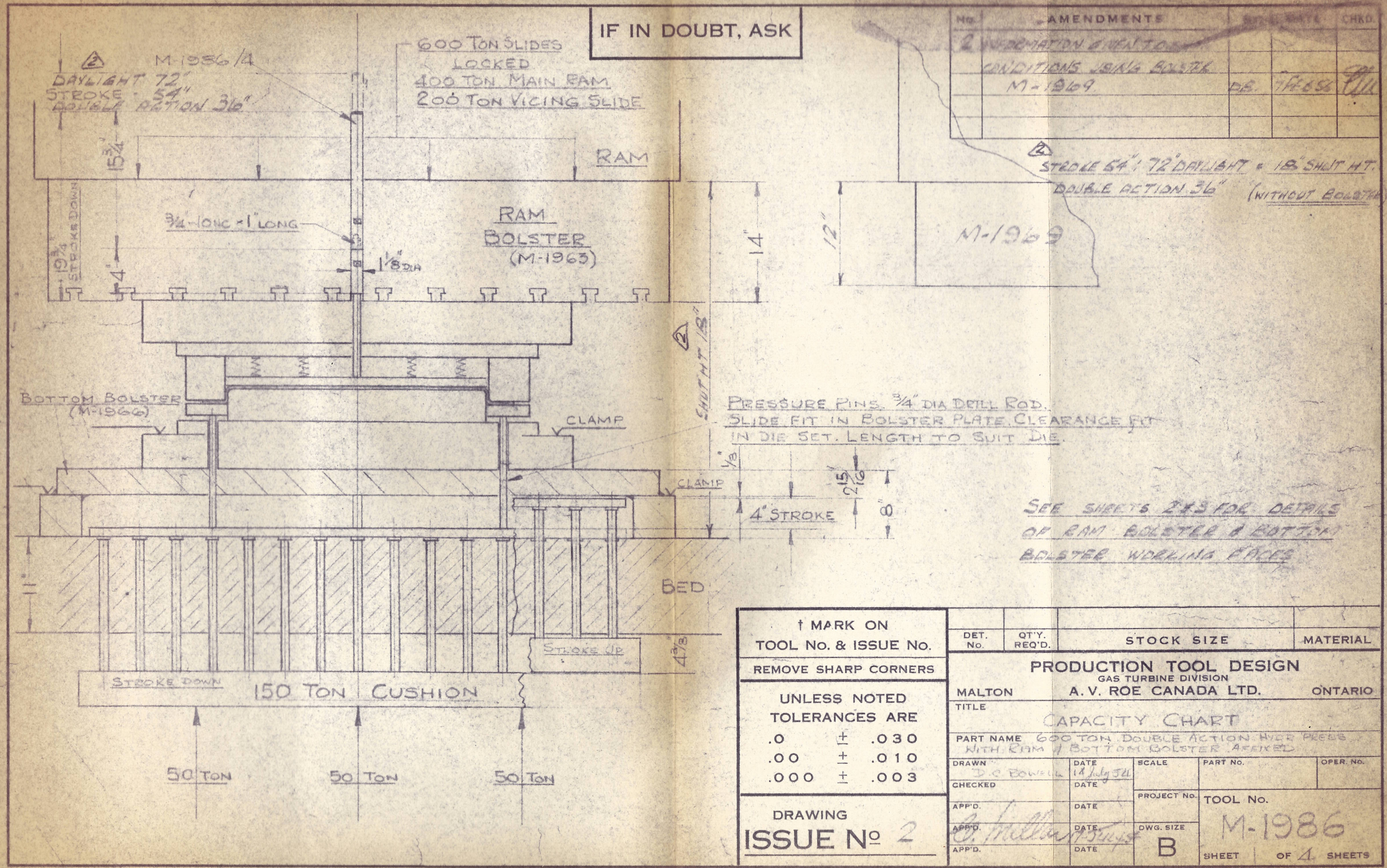
IF IN DOUBT, ASK

No.	AMENDMENTS		DATE	CHKD.
2	INFORMATION GIVEN TO CONDITIONS USING BOLSTER M-1969	DB.	7-Feb-54	[illegible]



† MARK ON TOOL No. & ISSUE No.

REMOVE SHARP CORNERS

UNLESS NOTED TOLERANCES ARE

.0	±	.030
.00	±	.010
.000	±	.003

DRAWING ISSUE No 2

DET. No.	QT'Y. REQ'D.	STOCK SIZE	MATERIAL

PRODUCTION TOOL DESIGN
GAS TURBINE DIVISION
MALTON — A. V. ROE CANADA LTD. — ONTARIO

TITLE: CAPACITY CHART

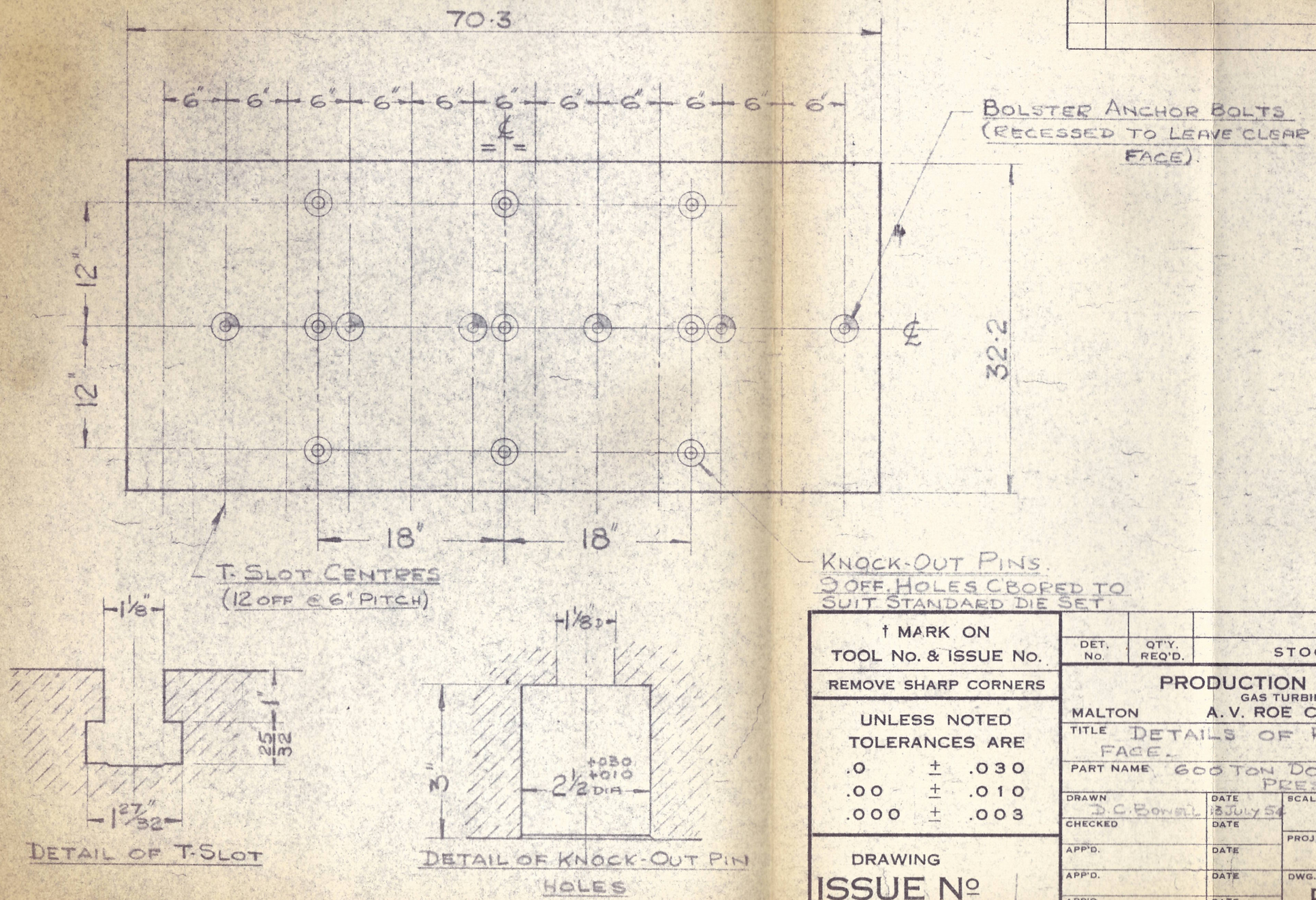
PART NAME: 600 TON DOUBLE ACTION HYDR PRESS WITH RAM & BOTTOM BOLSTER AFFIXED

DRAWN D.C. Bowell	DATE 14 July 54	SCALE	PART No.	OPER. No.
CHECKED	DATE	PROJECT No.	TOOL No. M-1986	
APP'D.	DATE			
APP'D. C. Miller	DATE 19 Aug 54	DWG. SIZE B		
APP'D.	DATE		SHEET	OF 4 SHEETS

AVRO P.G.T. 2159B

IF IN DOUBT, ASK

No.	AMENDMENTS	BY	DATE	CHKD.



† MARK ON TOOL No. & ISSUE No.

REMOVE SHARP CORNERS

UNLESS NOTED TOLERANCES ARE

.0	±	.030
.00	±	.010
.000	±	.003

DRAWING ISSUE No 1

DET. No.	QT'Y. REQ'D.	STOCK SIZE	MATERIAL

PRODUCTION TOOL DESIGN
GAS TURBINE DIVISION
MALTON — A. V. ROE CANADA LTD. — ONTARIO

TITLE: DETAILS OF RAM BOLSTER (M-1963) FACE.

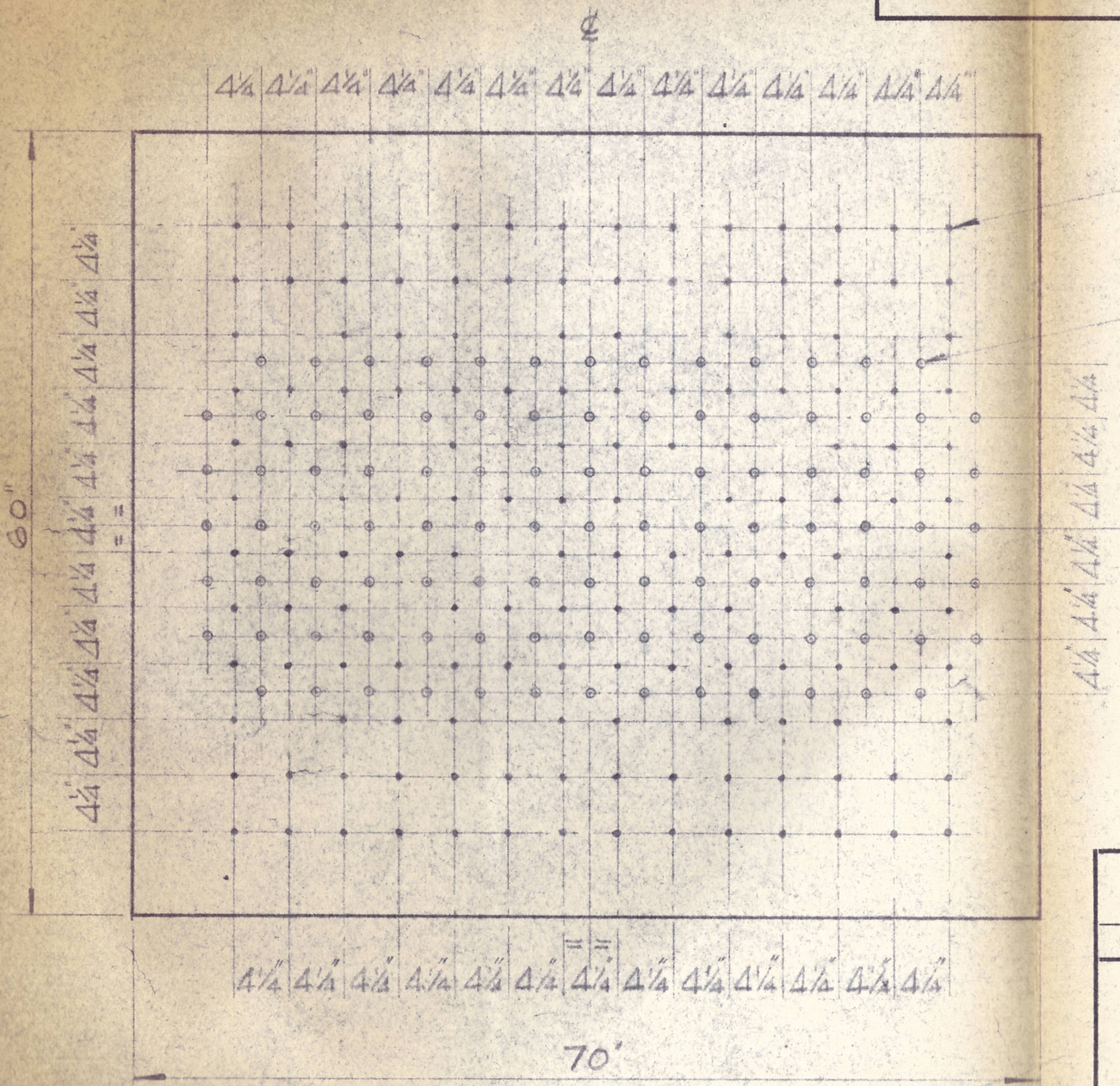
PART NAME: 600 TON DOUBLE ACTION HYDR PRESS

DRAWN: D.C. Bowell	DATE: 13 JULY 54	SCALE	PART No.	OPER. No.
CHECKED	DATE	PROJECT No.	TOOL No. M-1986	
APP'D.	DATE			
APP'D.	DATE	DWG. SIZE B		
APP'D.	DATE		SHEET 2 OF 4 SHEETS	

AVRO P.G.T. 2159B

IF IN DOUBT, ASK

No.	AMENDMENTS	BY	DATE	CHKD.



CLAMP HOLES (DIE SETS)
3/4 DIA - 10 NC x 2 DEEP

PRESSURE PIN HOLES.
101 OFF REAMED 3/4 DIA.

℄

† MARK ON
TOOL No. & ISSUE No.

REMOVE SHARP CORNERS

UNLESS NOTED
TOLERANCES ARE

.0	±	.030
.00	±	.010
.000	±	.003

DRAWING
ISSUE No 1

DET. No.	QT'Y. REQ'D.	STOCK SIZE	MATERIAL

PRODUCTION TOOL DESIGN
GAS TURBINE DIVISION
MALTON — A. V. ROE CANADA LTD. — ONTARIO

TITLE: DETAILS BOTTOM BOLSTER WORKING FACE (M-1966)

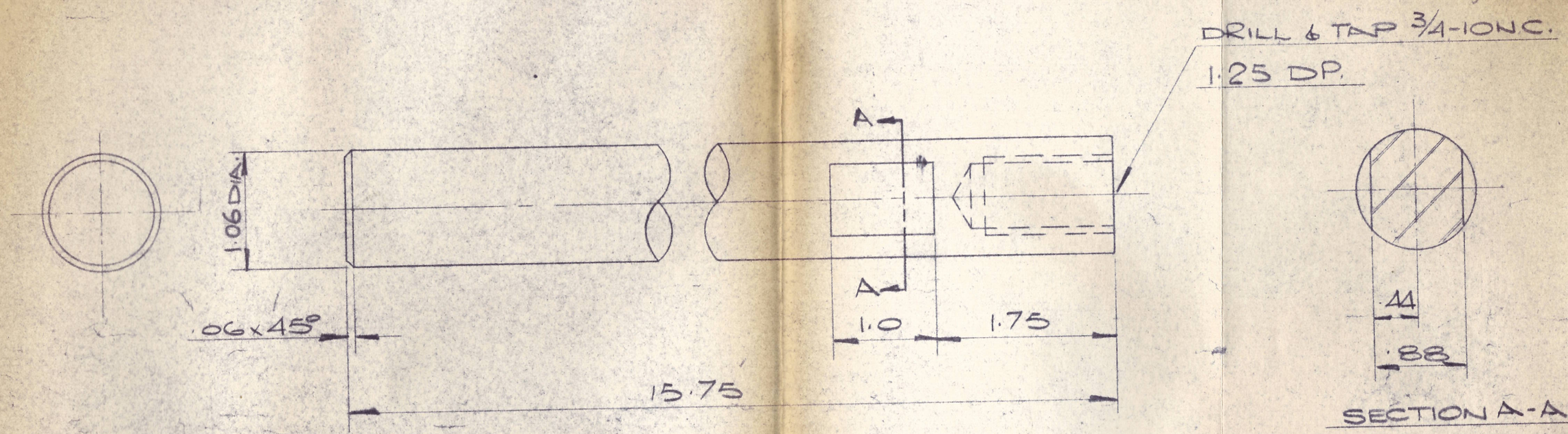
PART NAME: 600 TON DOUBLE ACTION HYDR PRESS

DRAWN: D.C. BOWELL	DATE: 14 JULY/54	SCALE: 1/10	PART No.	OPER. No.
CHECKED	DATE	PROJECT No.	TOOL No. M-1986	
APP'D.	DATE			
APP'D.	DATE	DWG. SIZE: B		
APP'D.	DATE		SHEET 3 OF 4 SHEETS	

AVRO P.O.T. 2000

IF IN DOUBT, ASK

No.	AMENDMENTS	BY	DATE	CHKD.



9 REQ'D. — ONE SET.

MAT'L. SPS 245

HDN. ROC. C 35-40

FOR USE ON

600 TON DOMINION

PRESS

† MARK ON TOOL No. & ISSUE No.

REMOVE SHARP CORNERS

UNLESS NOTED TOLERANCES ARE

.0 ± .030
.00 ± .010
.000 ± .003

DRAWING ISSUE Nº 1

DET. No.	QT'Y. REQ'D.	STOCK SIZE	MATERIAL
1	9	1¼ DIA. x 16' LG.	SPS 245

PRODUCTION TOOL DESIGN
GAS TURBINE DIVISION
MALTON — A. V. ROE CANADA LTD. — ONTARIO

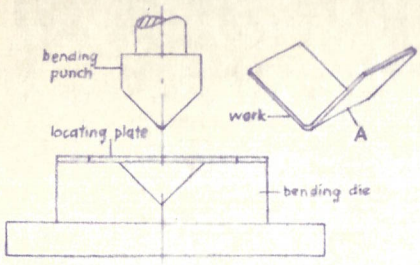
TITLE: KNOCK OUT PIN

PART NAME: —

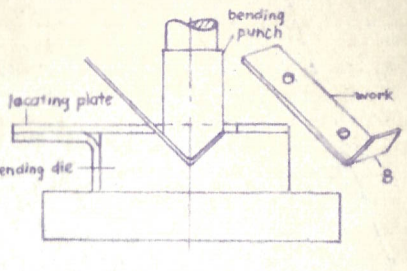
DRAWN: R Bullas	DATE: 17 Aug 54	SCALE: FULL	PART No.: —	OPER. No.: —
CHECKED: [illegible]	DATE: 20 Aug 54	PROJECT No.: 14	TOOL No.: M-1986	
APP'D.: [illegible]	DATE:			
APP'D.: C. Mellar	DATE: 20 Aug 54	DWG. SIZE: B		
APP'D.:	DATE:		SHEET 4 OF 4 SHEETS	

AVRO P.G.T. 2159B

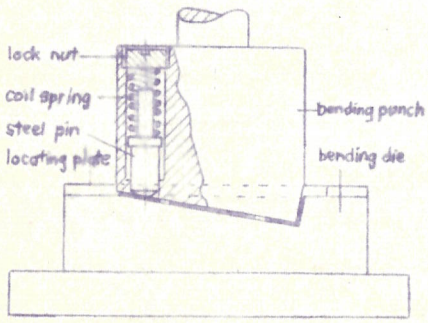
— How To Design An Efficient Die —



1



2



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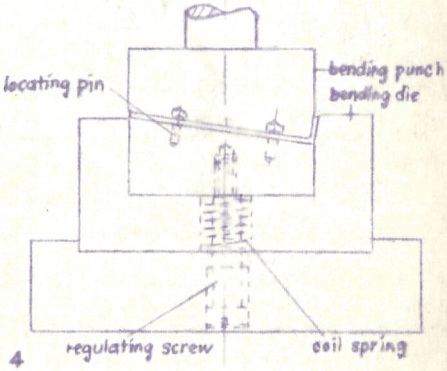

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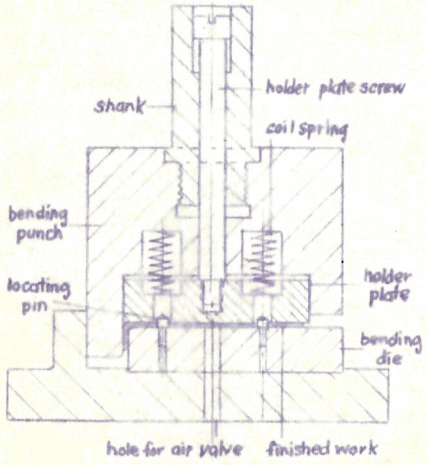

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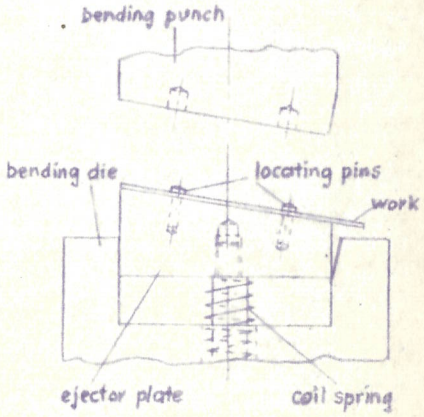

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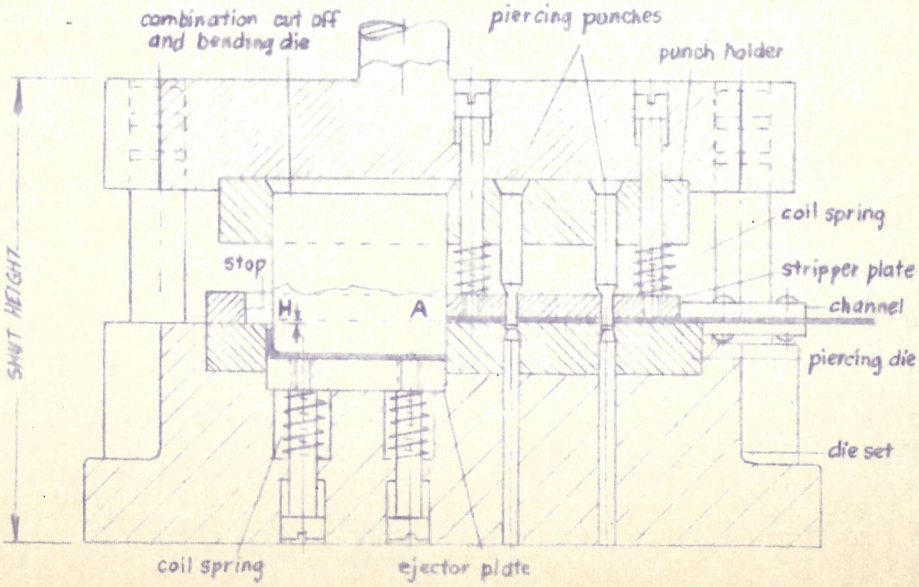


7

DRAWN	
CHECKED	
APPROV.	

STAMP TOOL WITH
DWG. NO.
SUB. NO.
D5-SK. No.
TOOL NO.

IT.	MT'L	NAME	SIZE	REQ.	WEIGHT
1					
2					
3					
4					
5					
6					

NO CHANGES IN CONSTRUCTION TO BE MADE WITHOUT NOTIFYING TOOL DESIGN

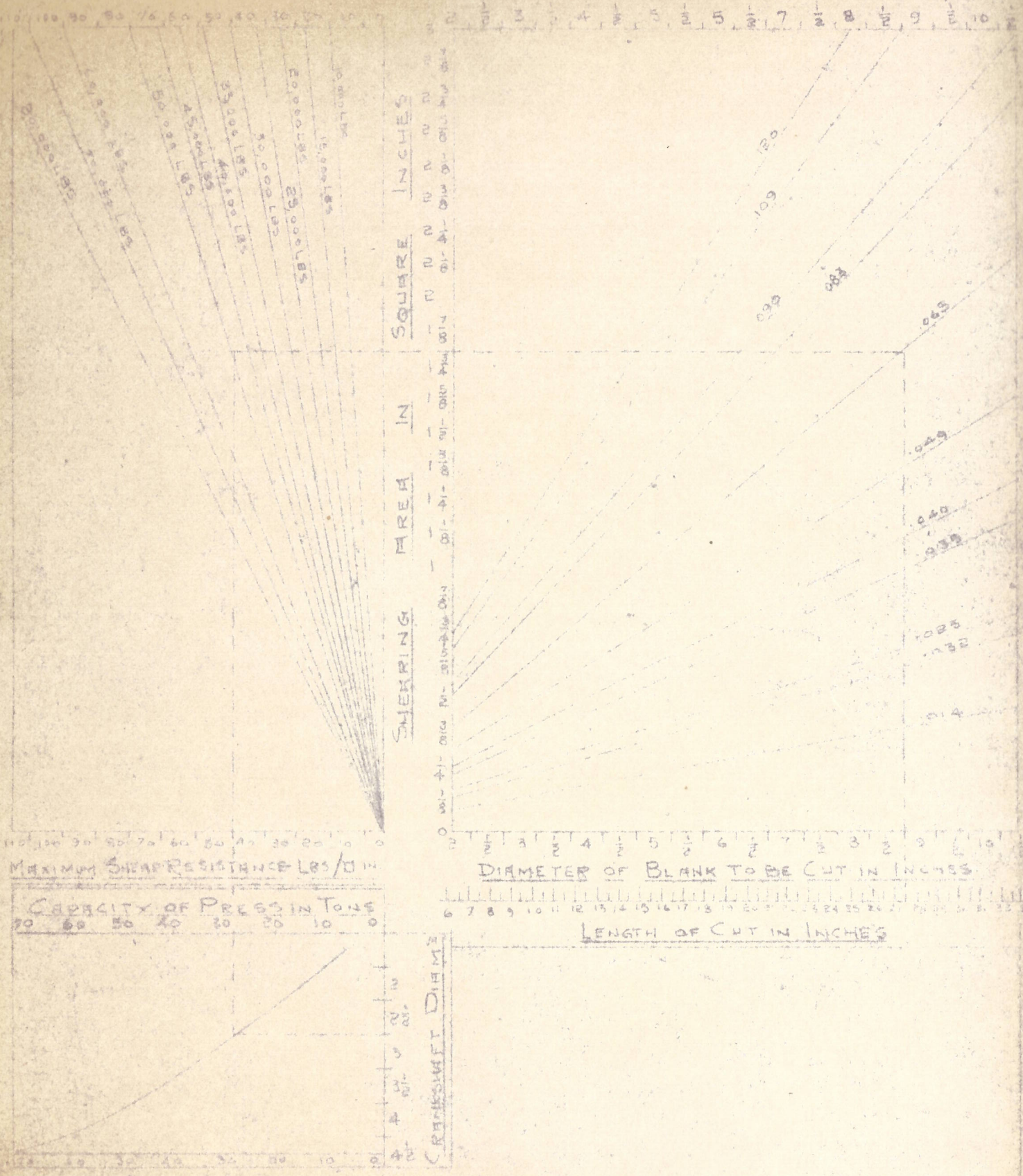
CAN. WESTINGHOUSE FORM 1115

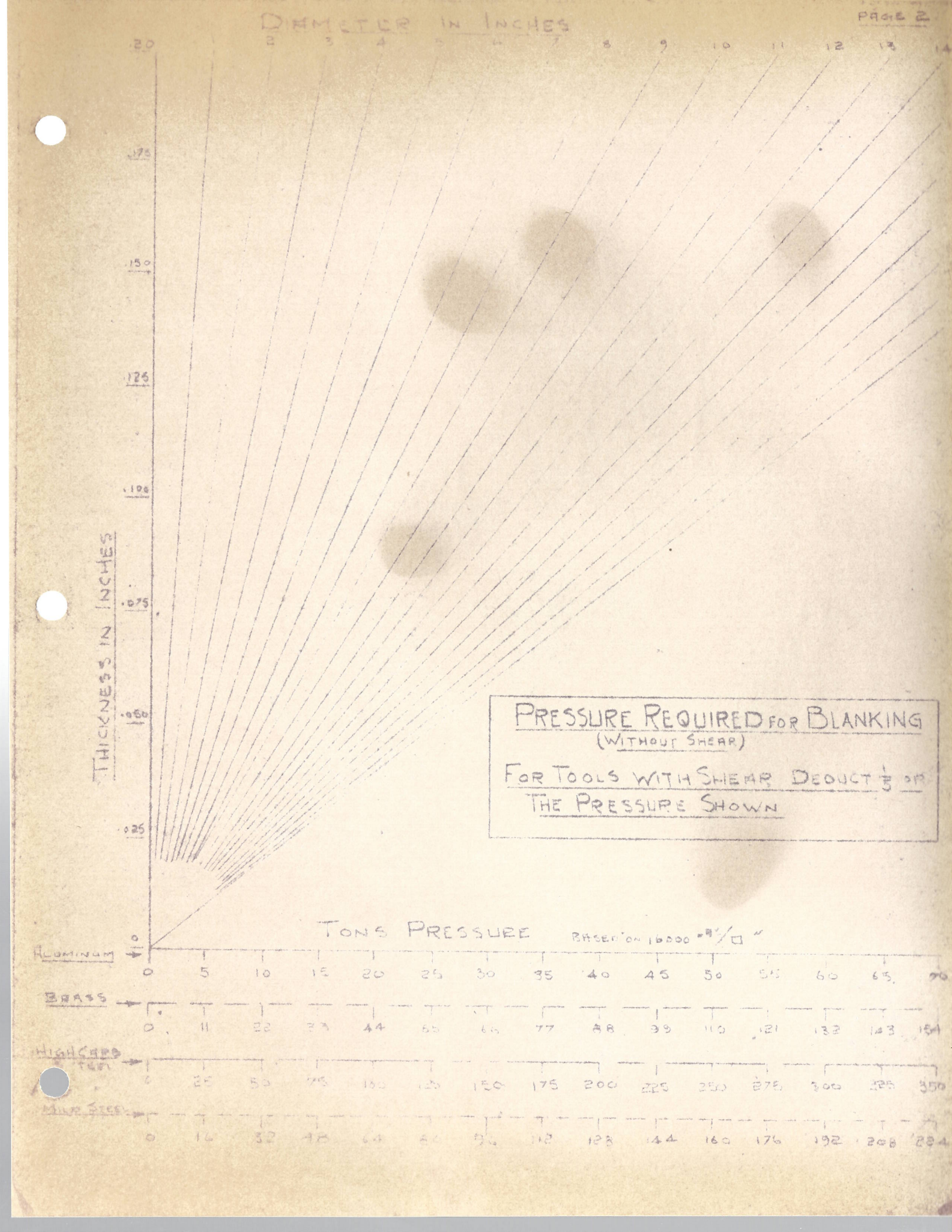
TOOL DESIGN

DWG. IT. SUB.

D5 - SK

SHEETS SHEET NO.


Shearing Area in Square Inches
Diameter of Blank to be Cut in Inches
Length of Cut in Inches
Maximum Shear Resistance Lbs/□ in
Capacity of Press in Tons
Crankshaft Diam


DIAMETER IN INCHES
2 3 4 5 6 7 8 9 10 11 12 13 14
THICKNESS IN INCHES
.200
.175
.150
.125
.100
.075
.050
.025
0
PRESSURE REQUIRED FOR BLANKING
(WITHOUT SHEAR)
FOR TOOLS WITH SHEAR DEDUCT 1/3 OF
THE PRESSURE SHOWN
TONS PRESSURE
BASED ON 16000 #/□"
ALUMINUM
0 5 10 15 20 25 30 35 40 45 50 55 60 65 70
BRASS
0 11 22 33 44 55 66 77 88 99 110 121 132 143 154
HIGH CARB STEEL
0 25 50 75 100 125 150 175 200 225 250 275 300 325 350
MILD STEEL
0 16 32 48 64 80 96 112 128 144 160 176 192 208 224

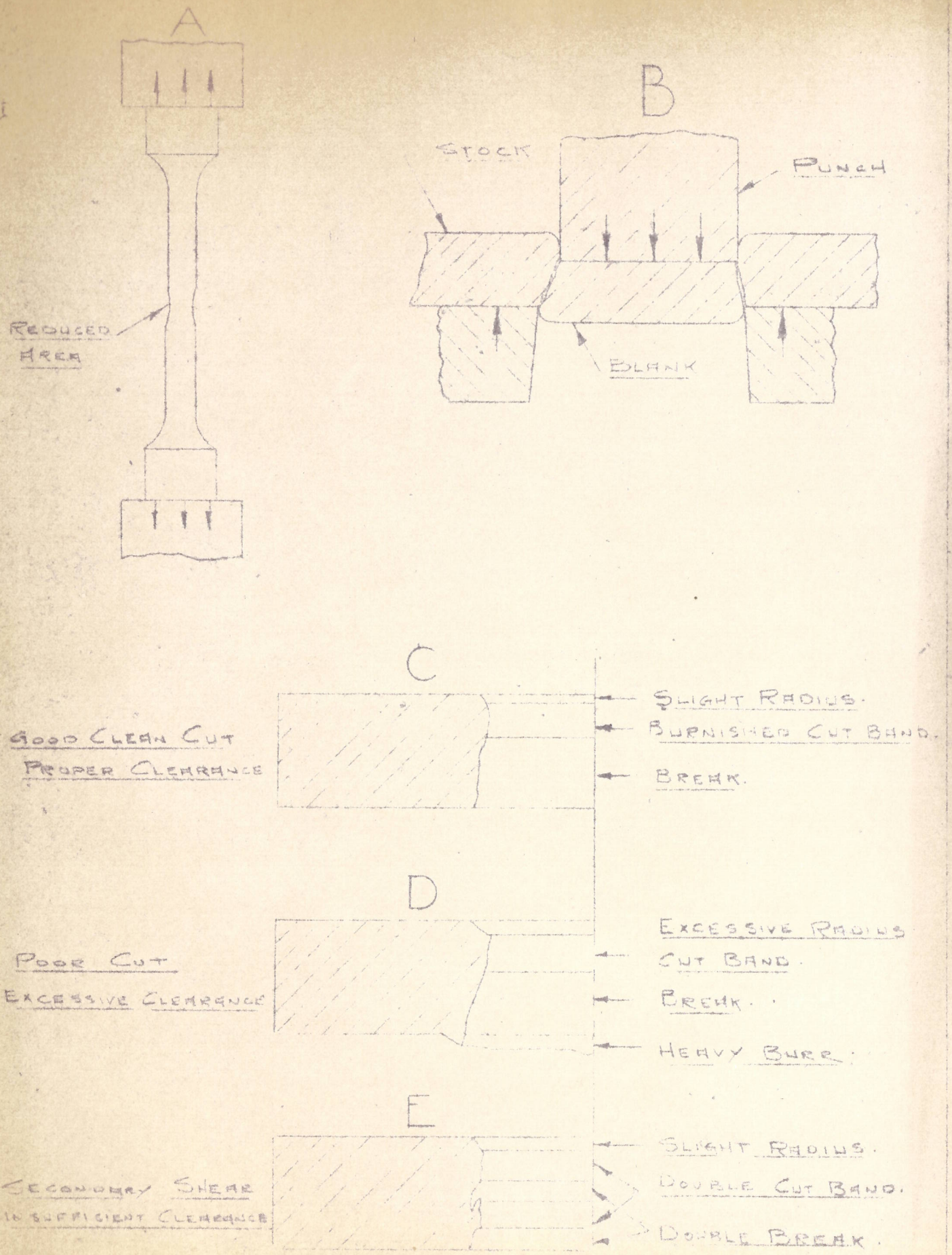

A
REDUCED AREA
B
STOCK
PUNCH
BLANK
C
GOOD CLEAN CUT
PROPER CLEARANCE
SLIGHT RADIUS.
BURNISHED CUT BAND.
BREAK.
D
POOR CUT
EXCESSIVE CLEARANCE
EXCESSIVE RADIUS
CUT BAND.
BREAK.
HEAVY BURR.
E
SECONDARY SHEAR
INSUFFICIENT CLEARANCE
SLIGHT RADIUS.
DOUBLE CUT BAND.
DOUBLE BREAK.

FIG 1

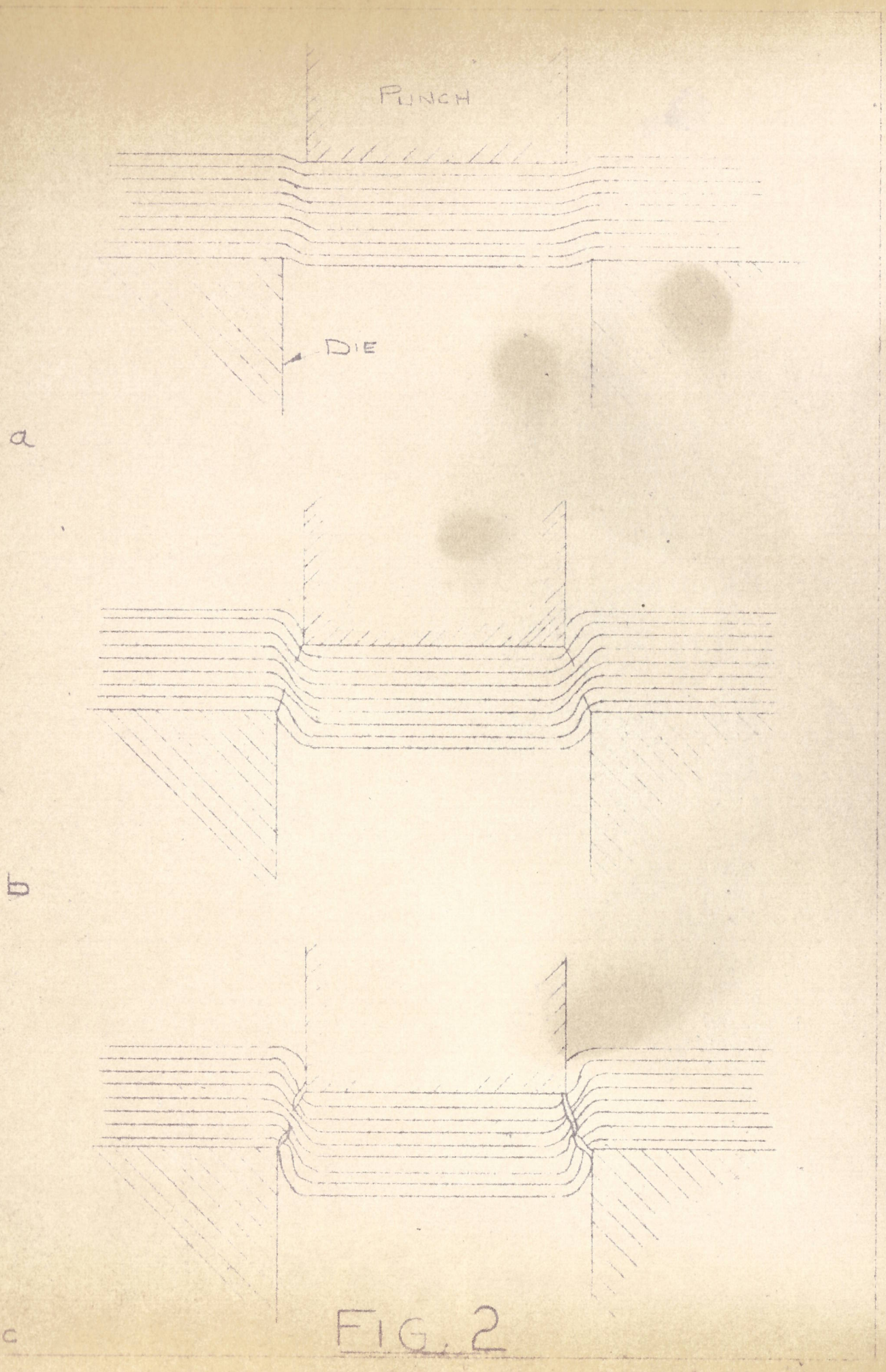
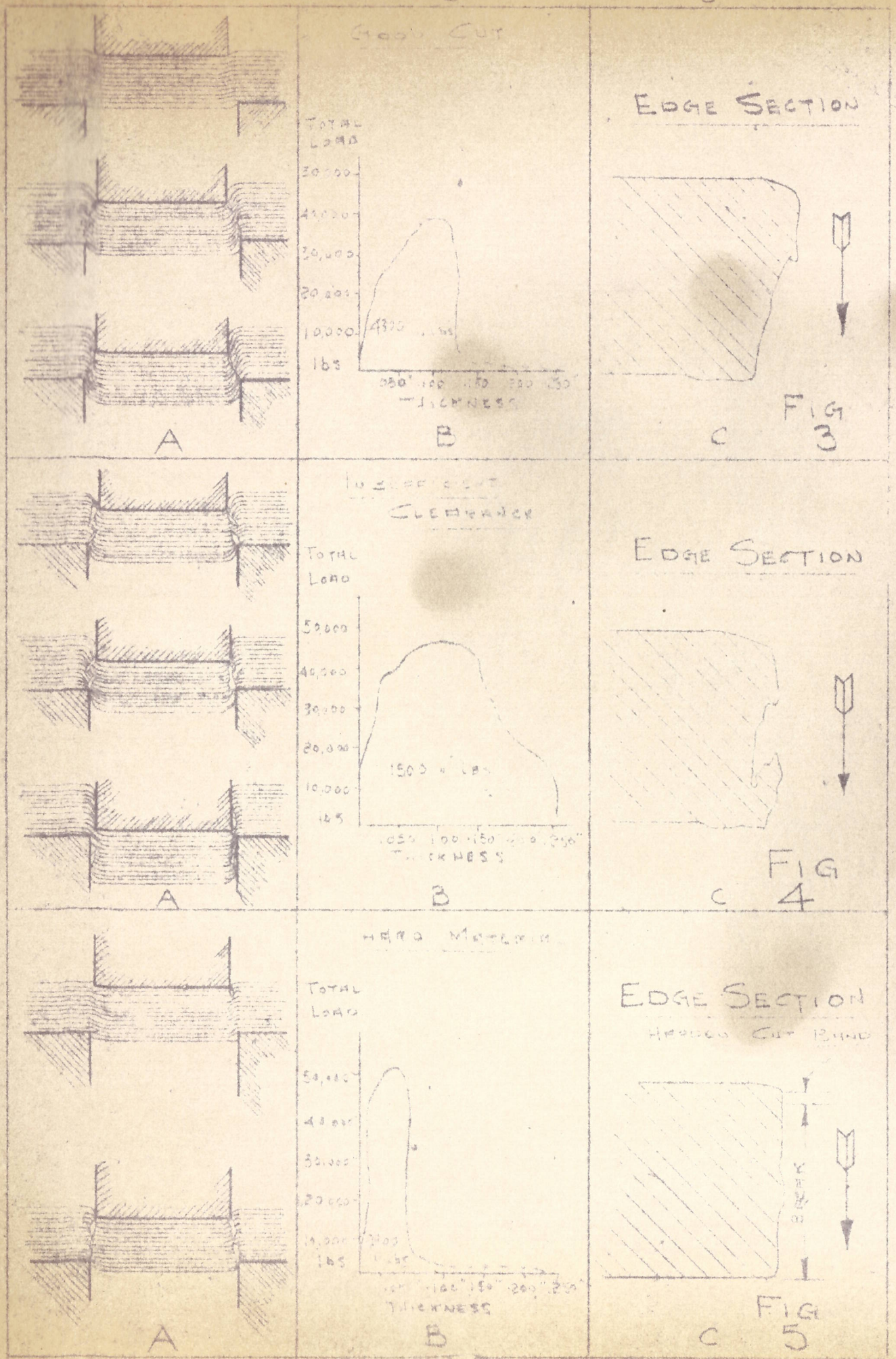
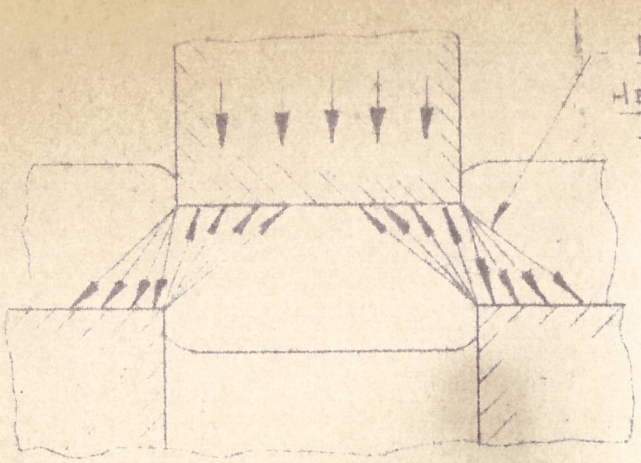


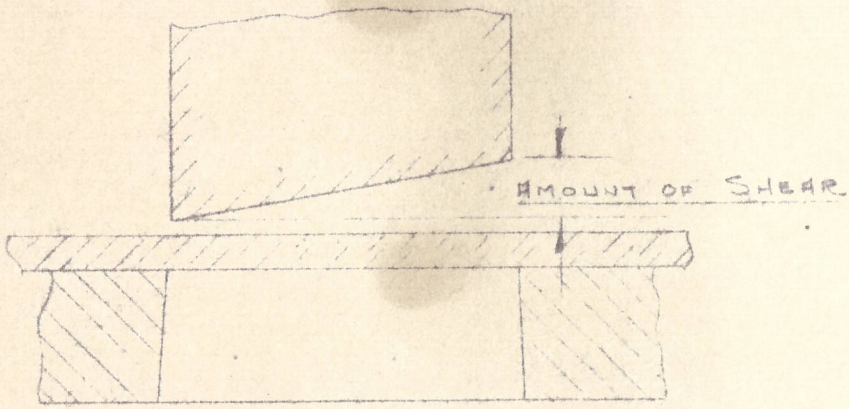
FIG. 2

a b c

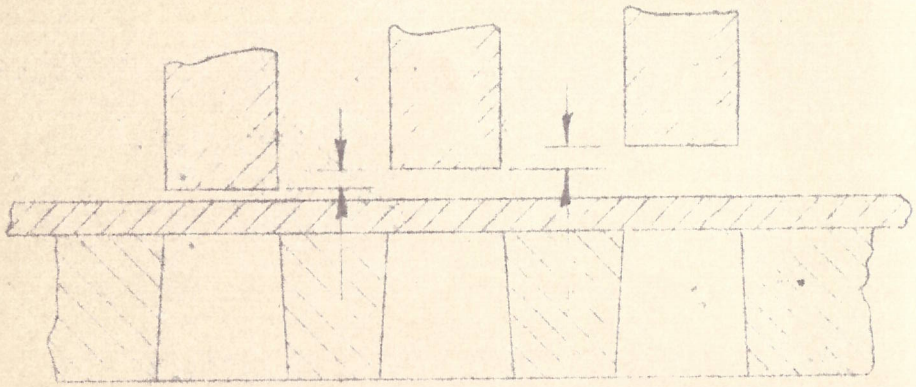

Good Cut
Total Load
30,000
40,000
20,000
10,000
lbs
4300 lbs
Thickness
Edge Section
A
B
C
Fig 3
Clearance
Total Load
50,000
40,000
30,000
20,000
10,000
lbs
1500 lbs
Thickness
Edge Section
A
B
C
Fig 4
Total Load
50,000
40,000
30,000
20,000
10,000
lbs
Thickness
Edge Section
A
B
C
Fig 5



COMPONENTS OF VERTICAL FORCE

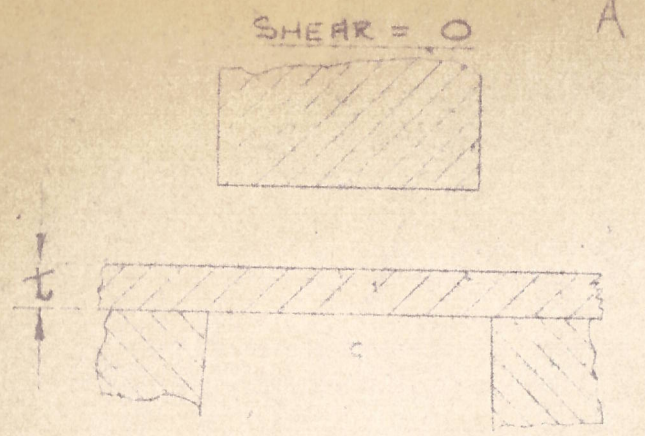


PUNCH GROUND WITH SHEAR



STAGGERED PUNCHES

FIG. 6.



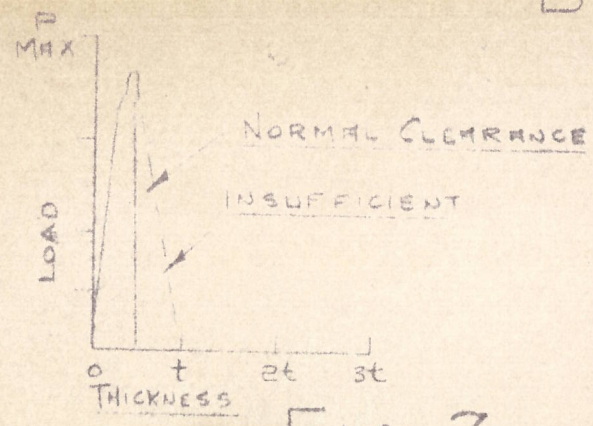
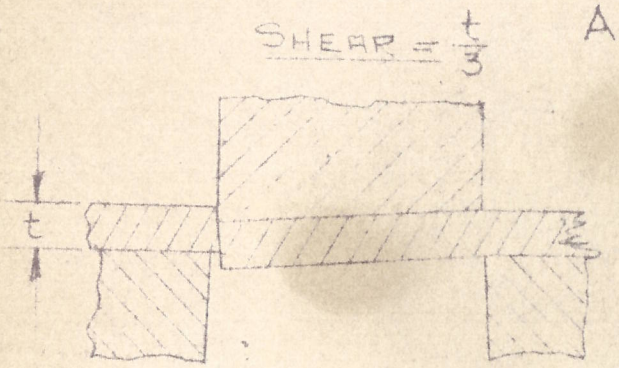


FIG 7



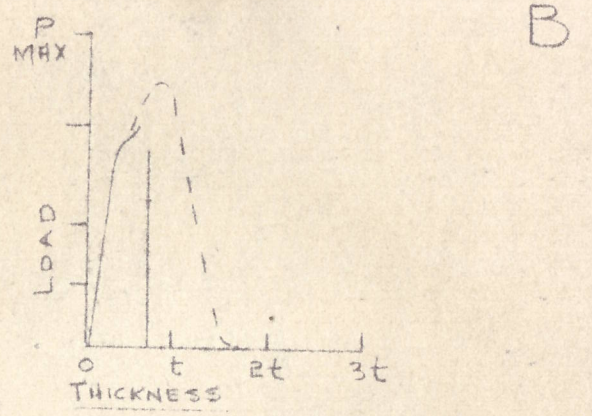
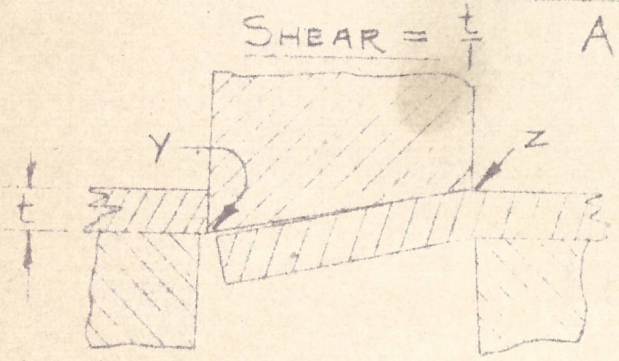


FIG 8



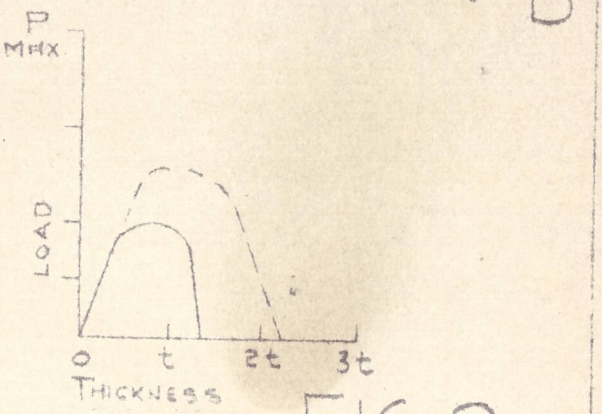


FIG 9

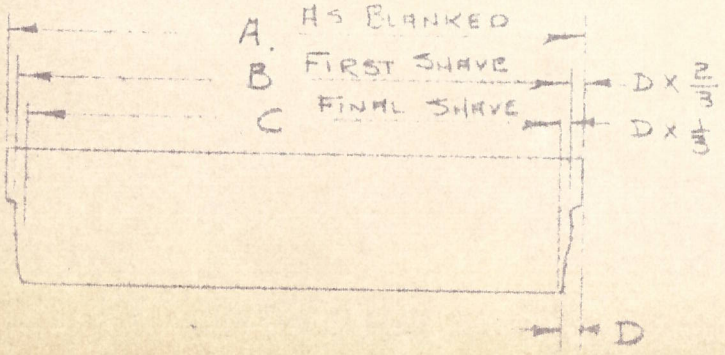
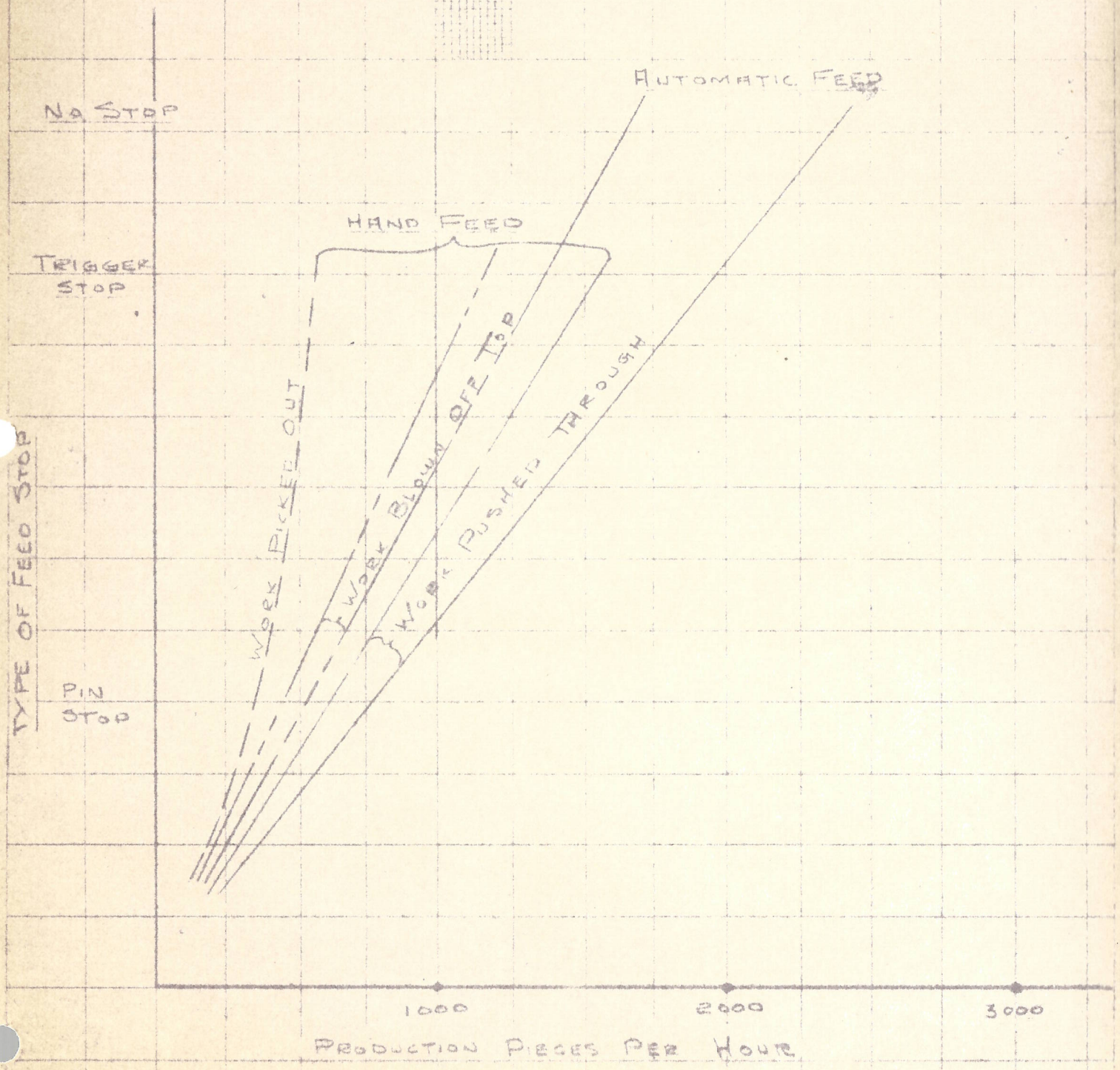


FIG 10

RELATION OF DIE DETAILS TO PRODUCTION



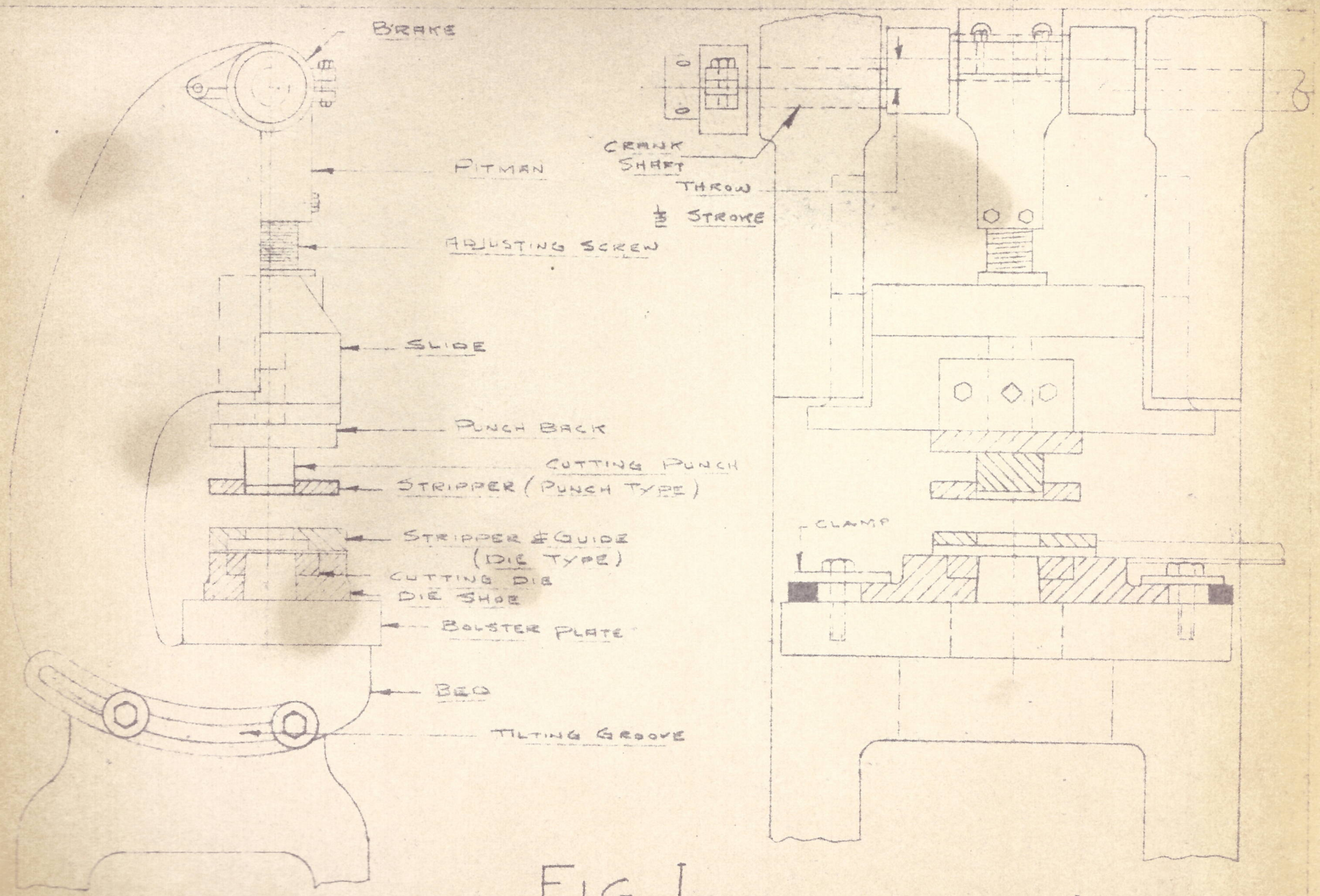
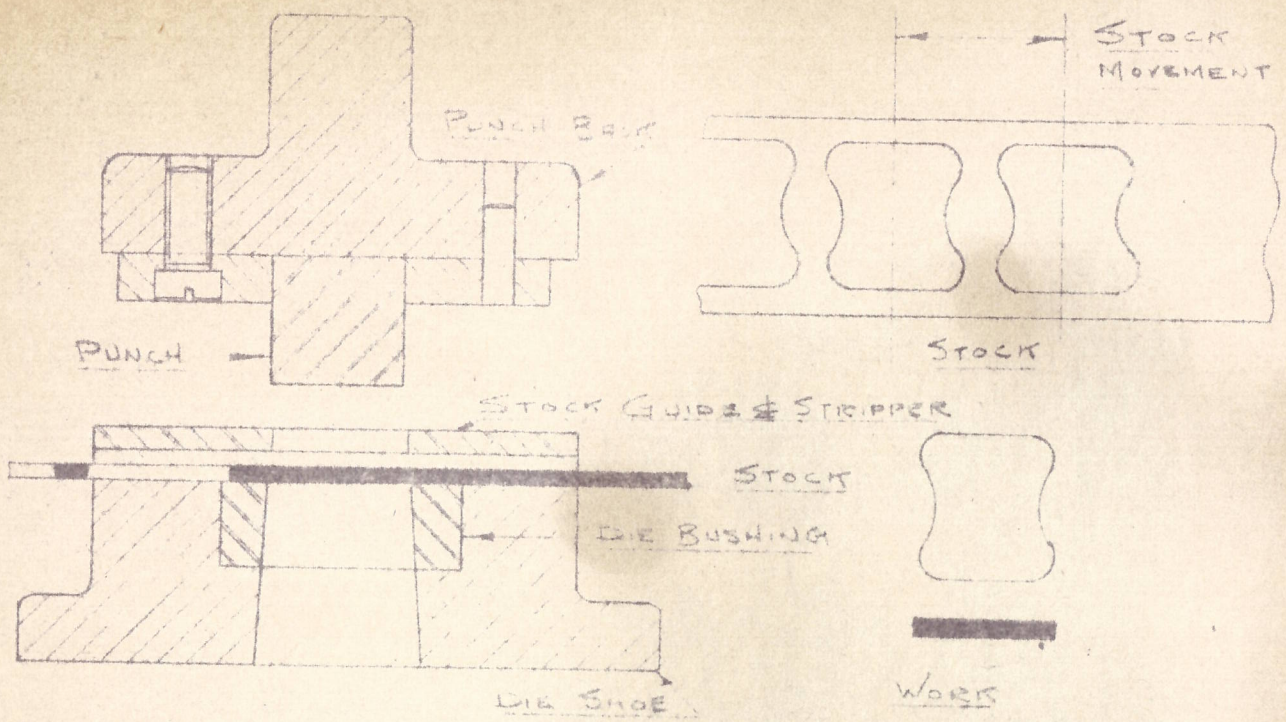


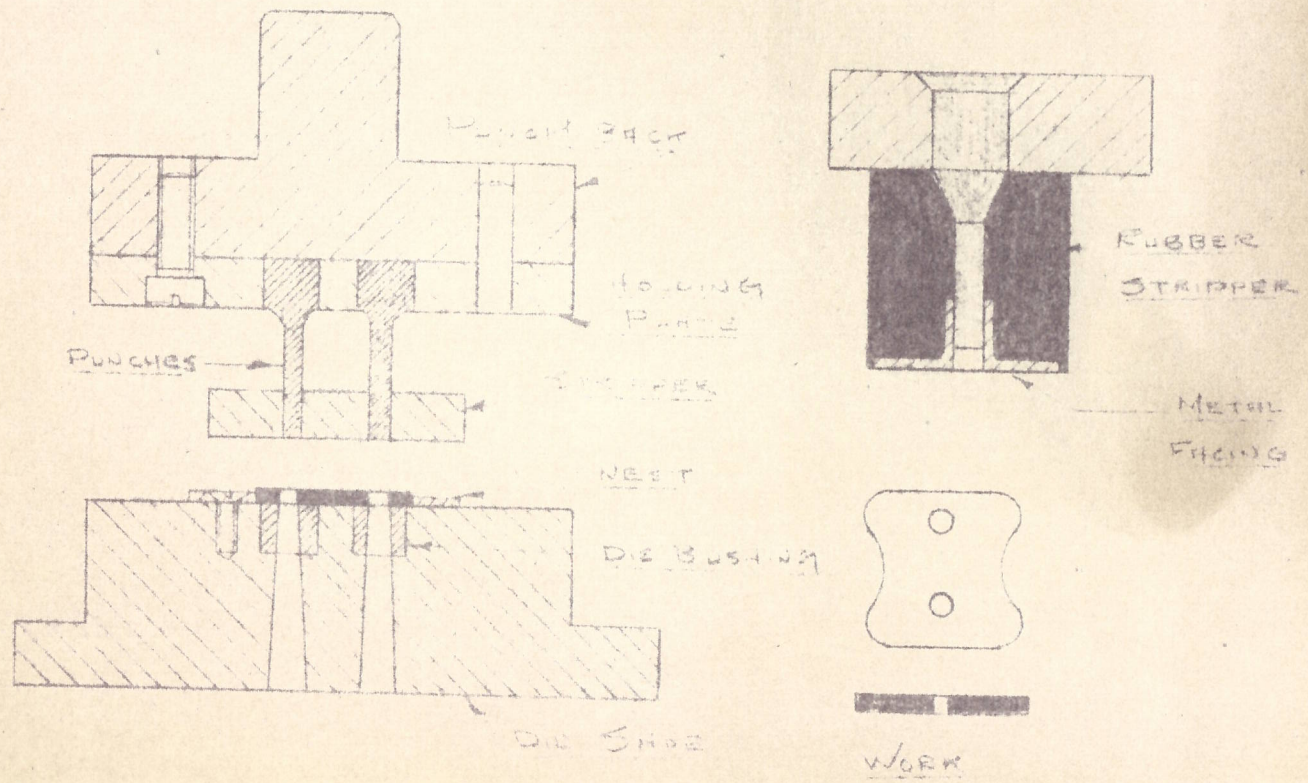
FIG I

SIMPLE BLANKING TOOL IN A SINGLE ACTION PUNCH PRESS



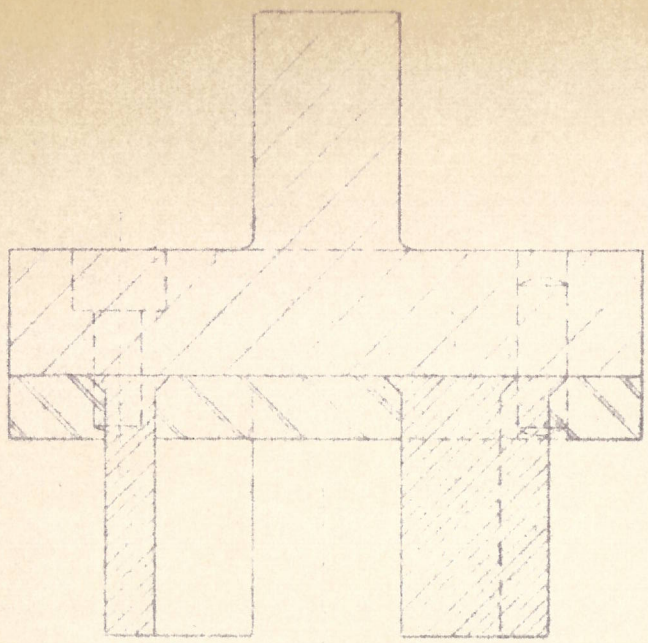
SIMPLE BLANKING TOOL

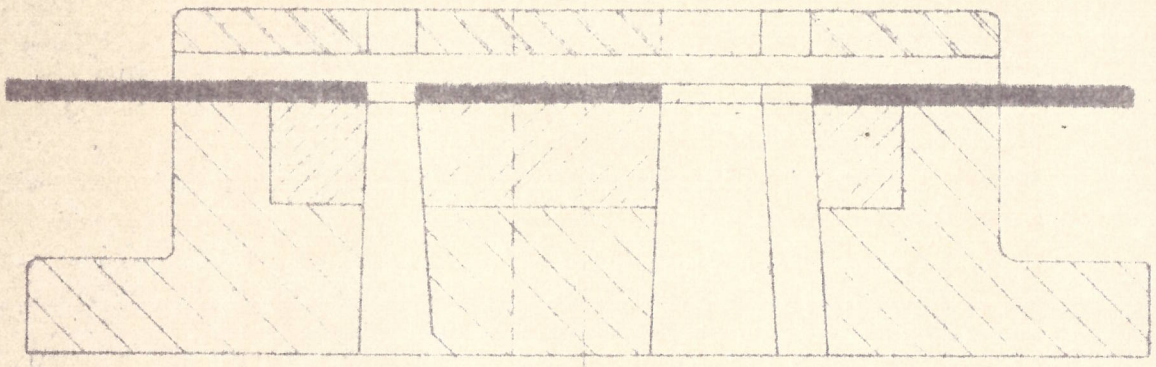
FIG. 2

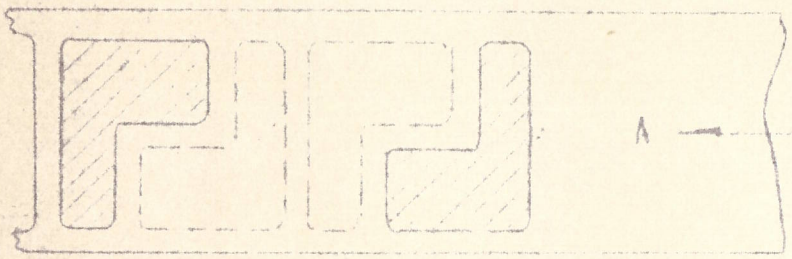


SIMPLE PIERCING TOOL

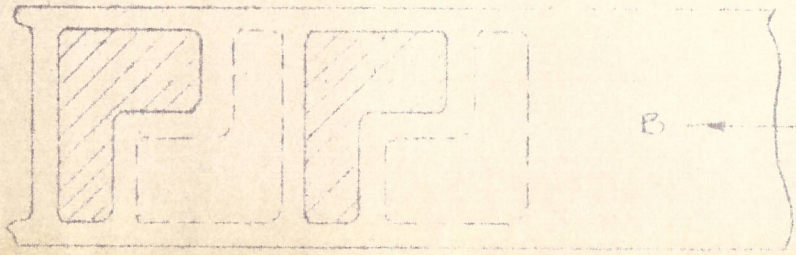
FIG. 3







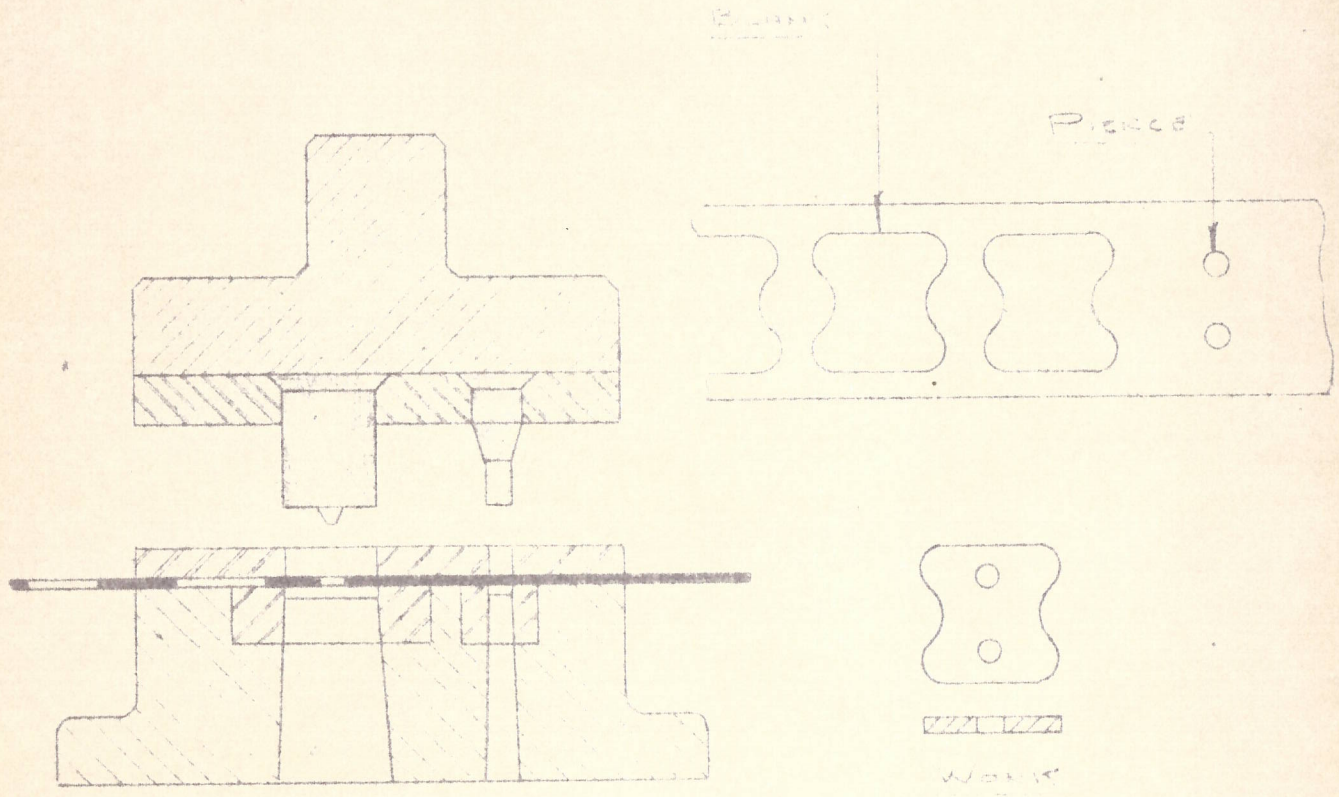
STOCK LAYOUT FOR MULTIPLE DIE STOCK FED THRO' THE DIE ONCE



STOCK LAYOUT FOR SIMPLE OR MULTIPLE DIE STOCK FED THRO' THE DIE TWICE

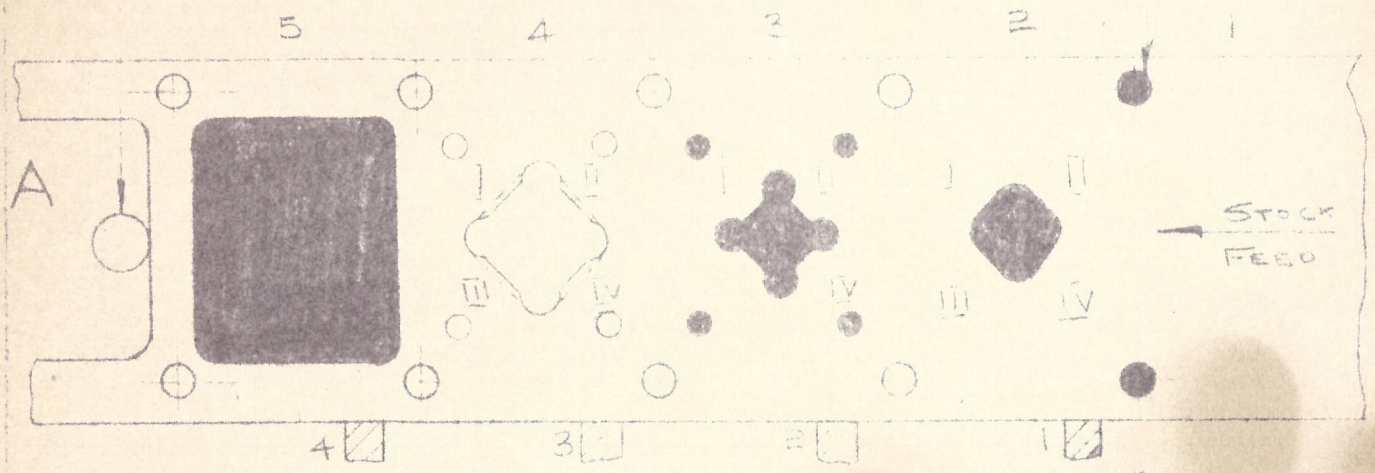
MULTIPLE OR GANG DIE

FIG 6



PROGRESSIVE DIE

FIG 7



B

STATION	WORK DONE
1	PIERCE 2 PILOT HOLES
2	LOCATE IN PILOT HOLES AND CUT SQUARE STAMP ROMAN NUMERALS
3	LOCATE IN PILOT HOLES, PIERCE 4 HOLES AND ELONGATE THE SQUARE
4	LOCATE IN PILOT HOLES, & FORM 4 LIPS
5	LOCATE IN PILOT HOLES, & BLANK OUT

STATION STOPS 1, 2, 3 & 4 USED FOR FIRST 4 STEPS ON NEW STRIP OF STOCK, TRIGGER STOP USED FROM THERE ON TO THE END OF STRIP OR COIL

C

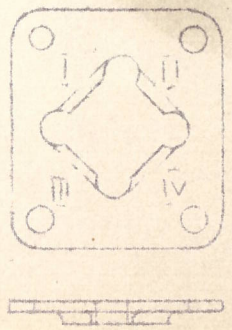
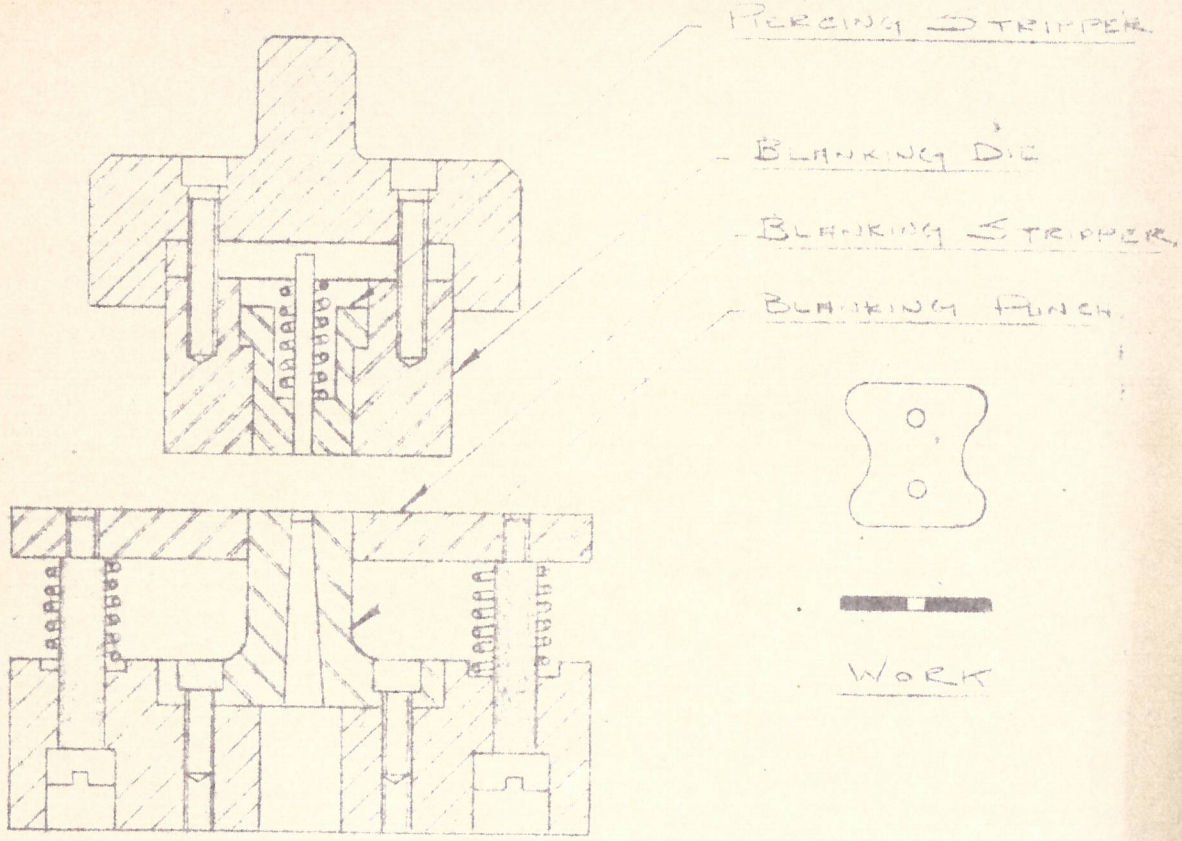


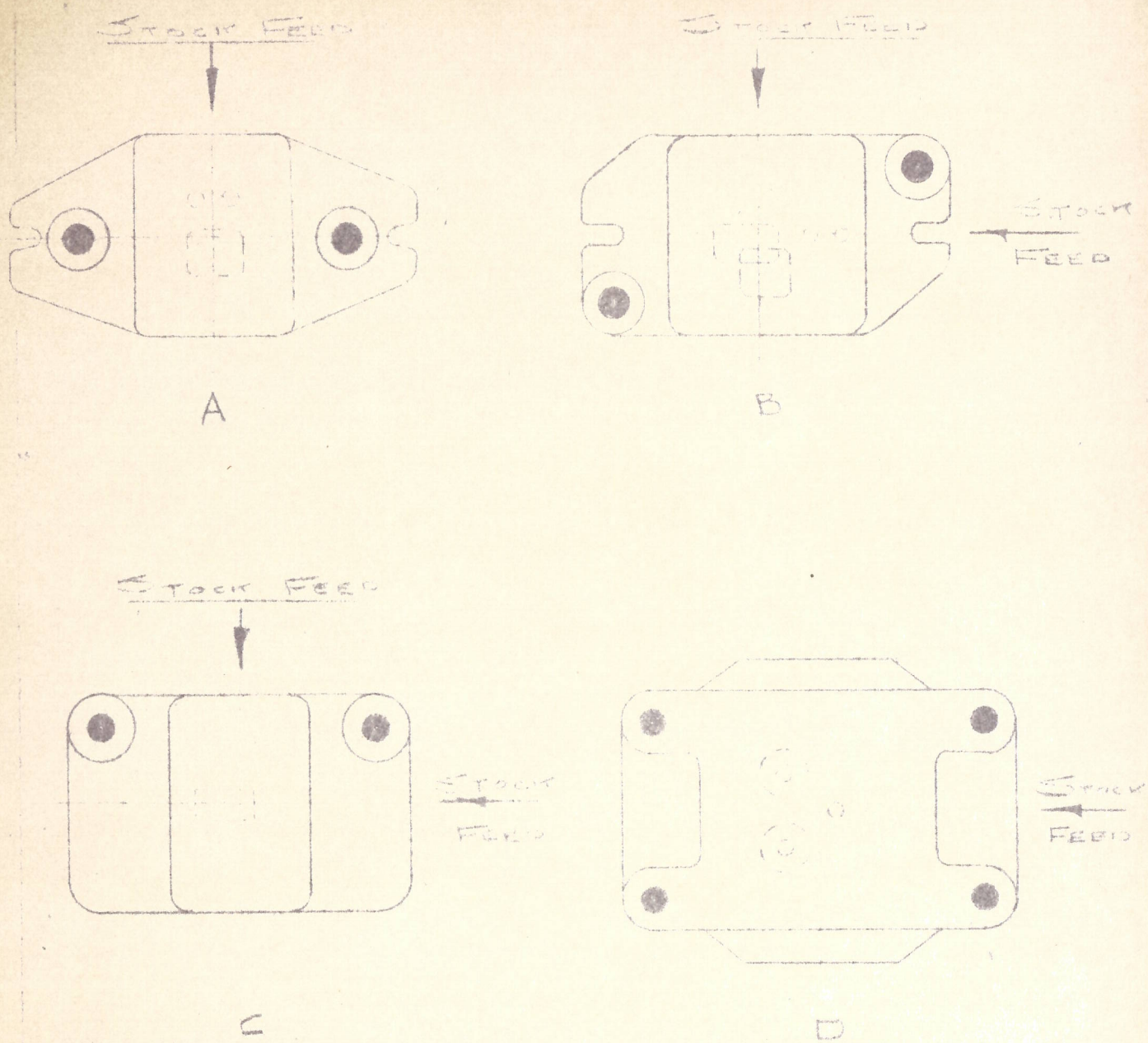
FIG. 8

STOCK LAYOUT FOR A PROGRESSIVE DIE



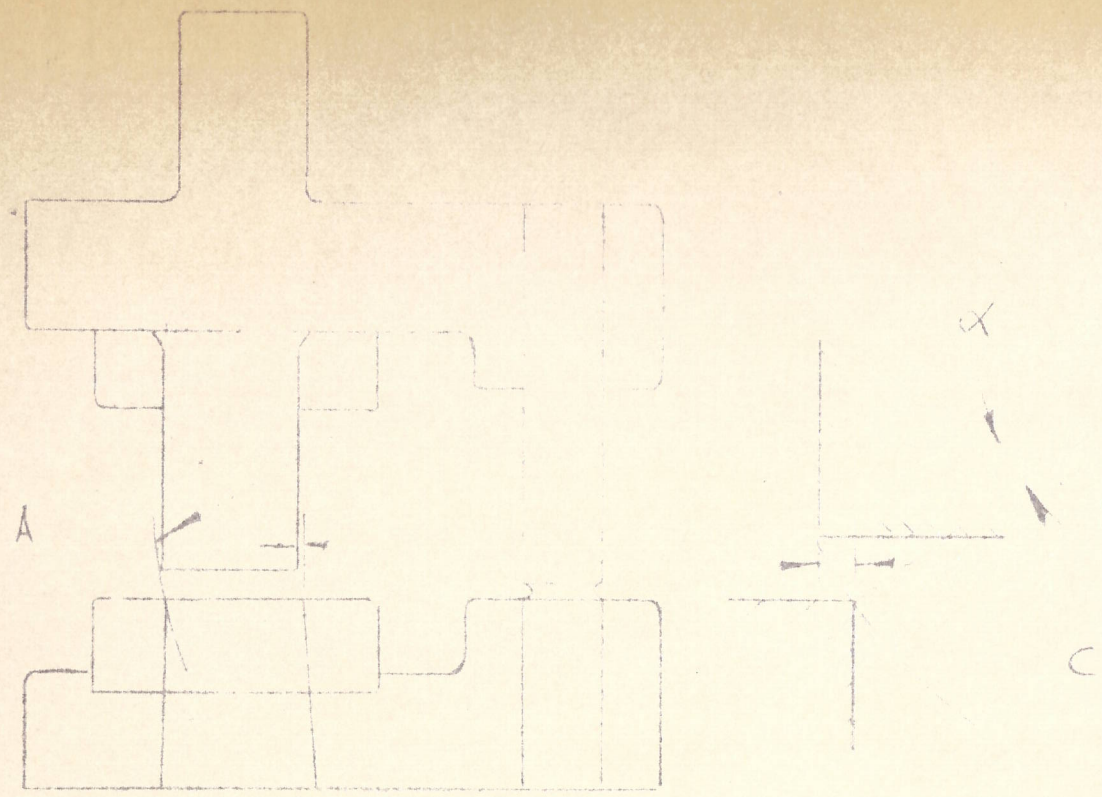
COMPOUND DIE

FIG 9

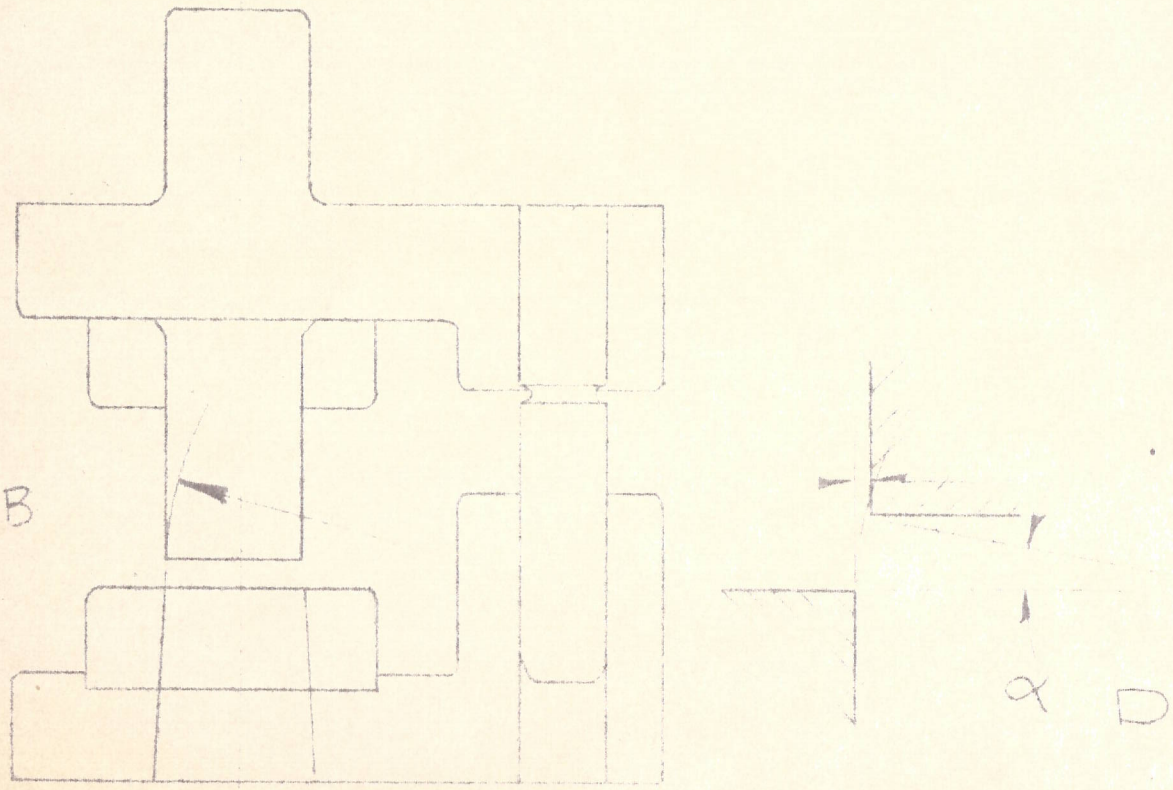


GUIDE PIN ARRANGEMENTS

FIGURE 10

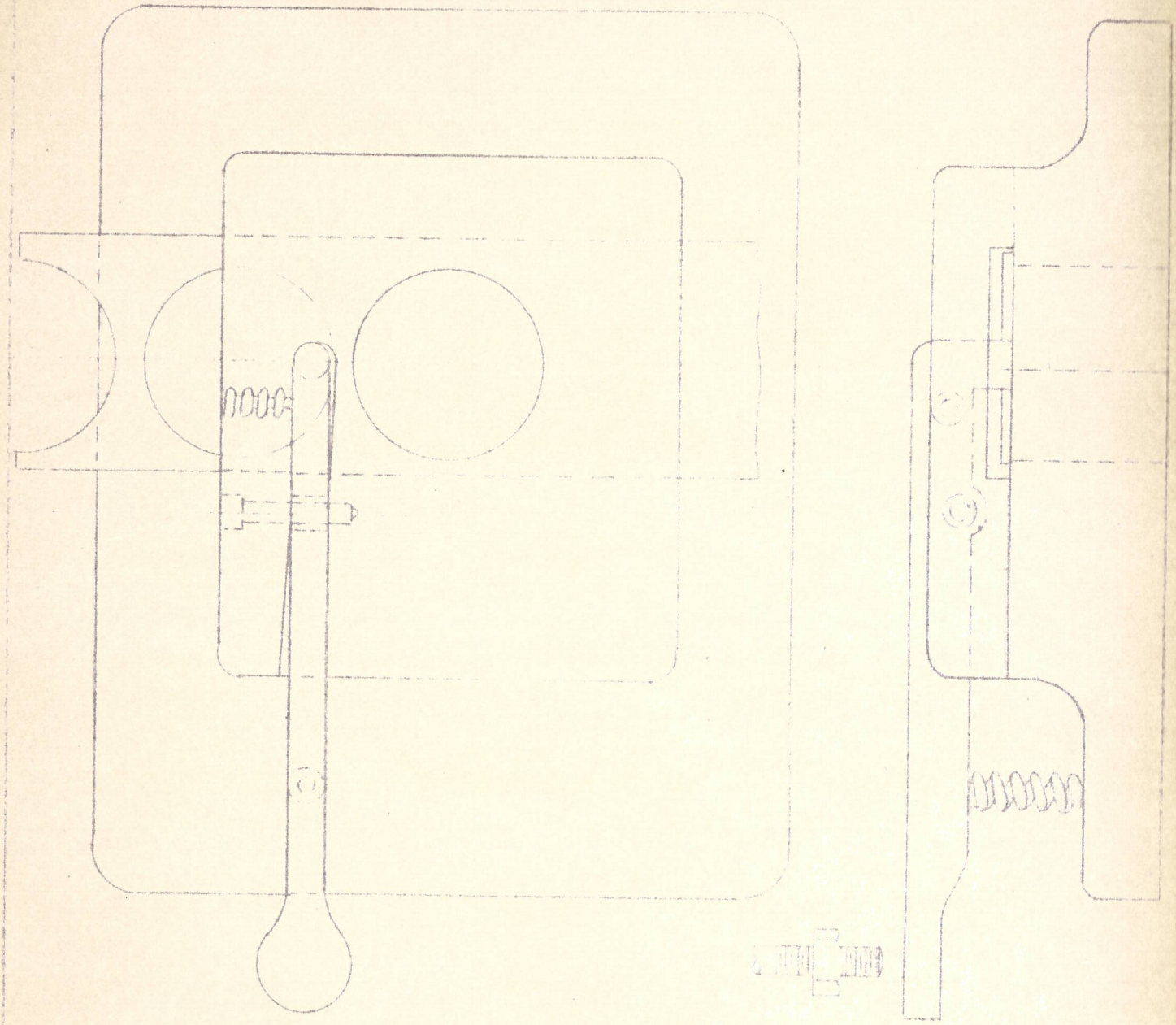


TUBE ARRANGEMENT



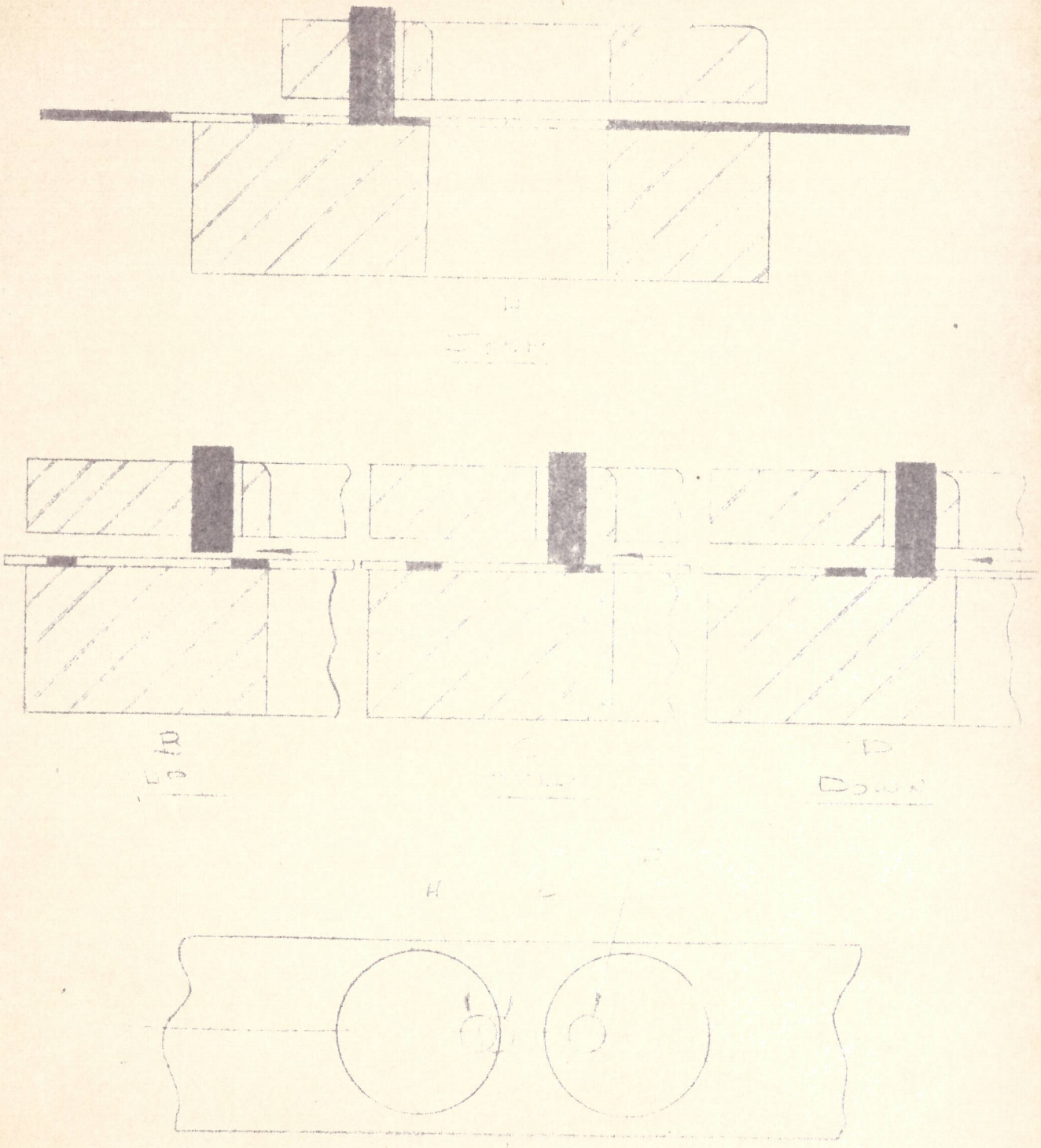
EFFICIENCY / O. G. VERSUS THE CENTRE OF PRESSURE

FIG. 11



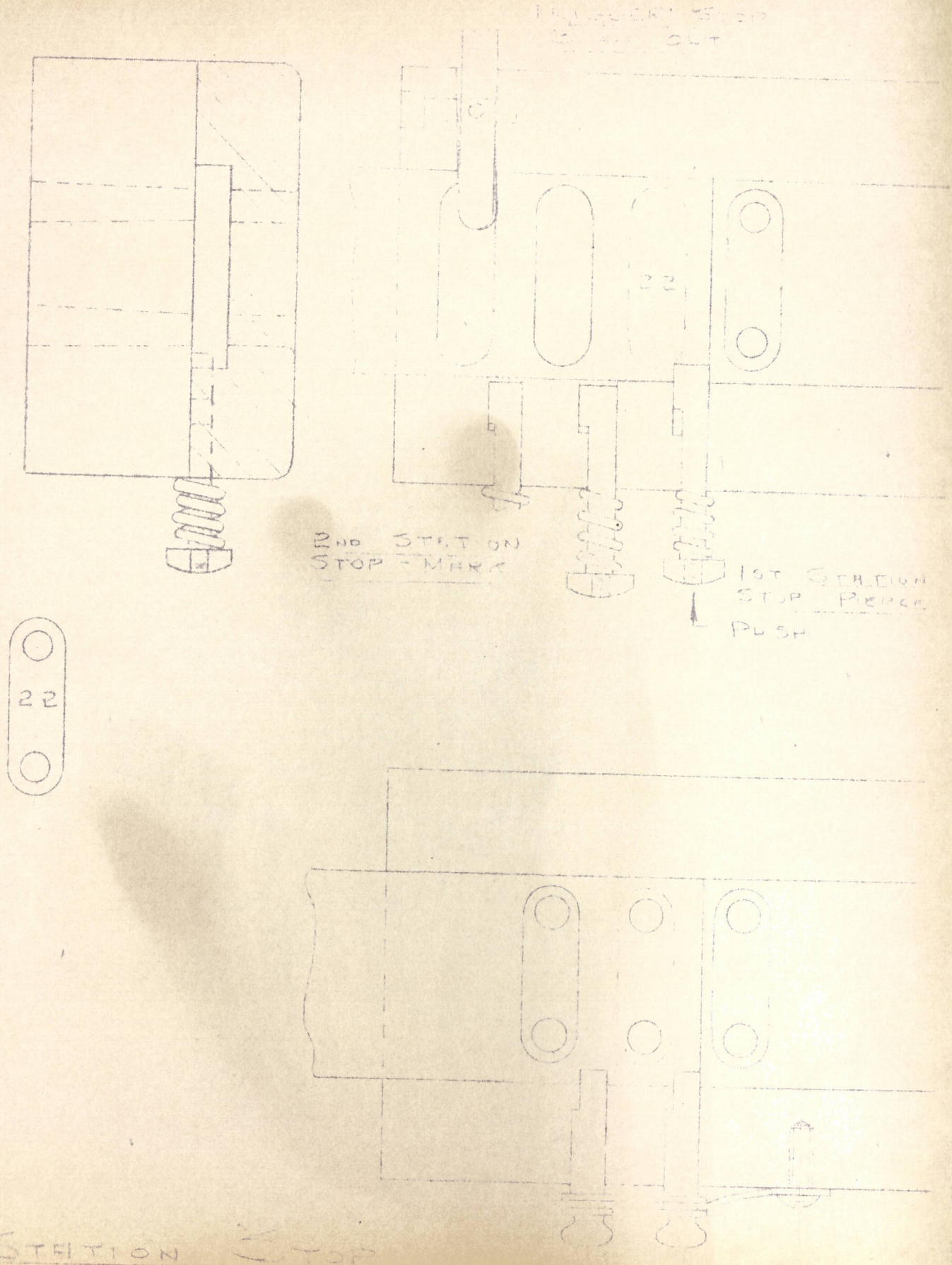
TRIGGER STOP

FIG 13



TRIGGER STOP ACTION

FIG 14



STATION STOP

FIG 16

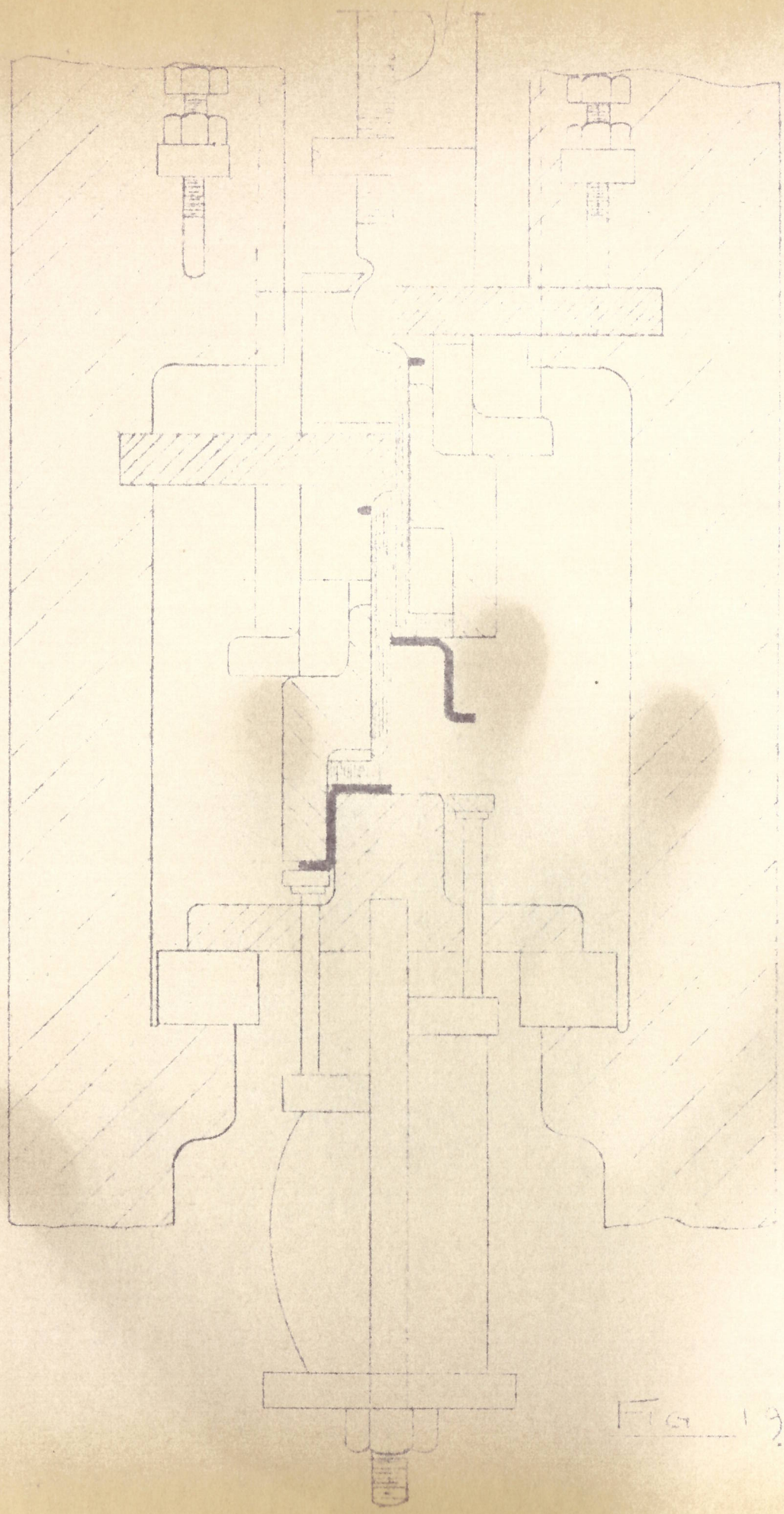
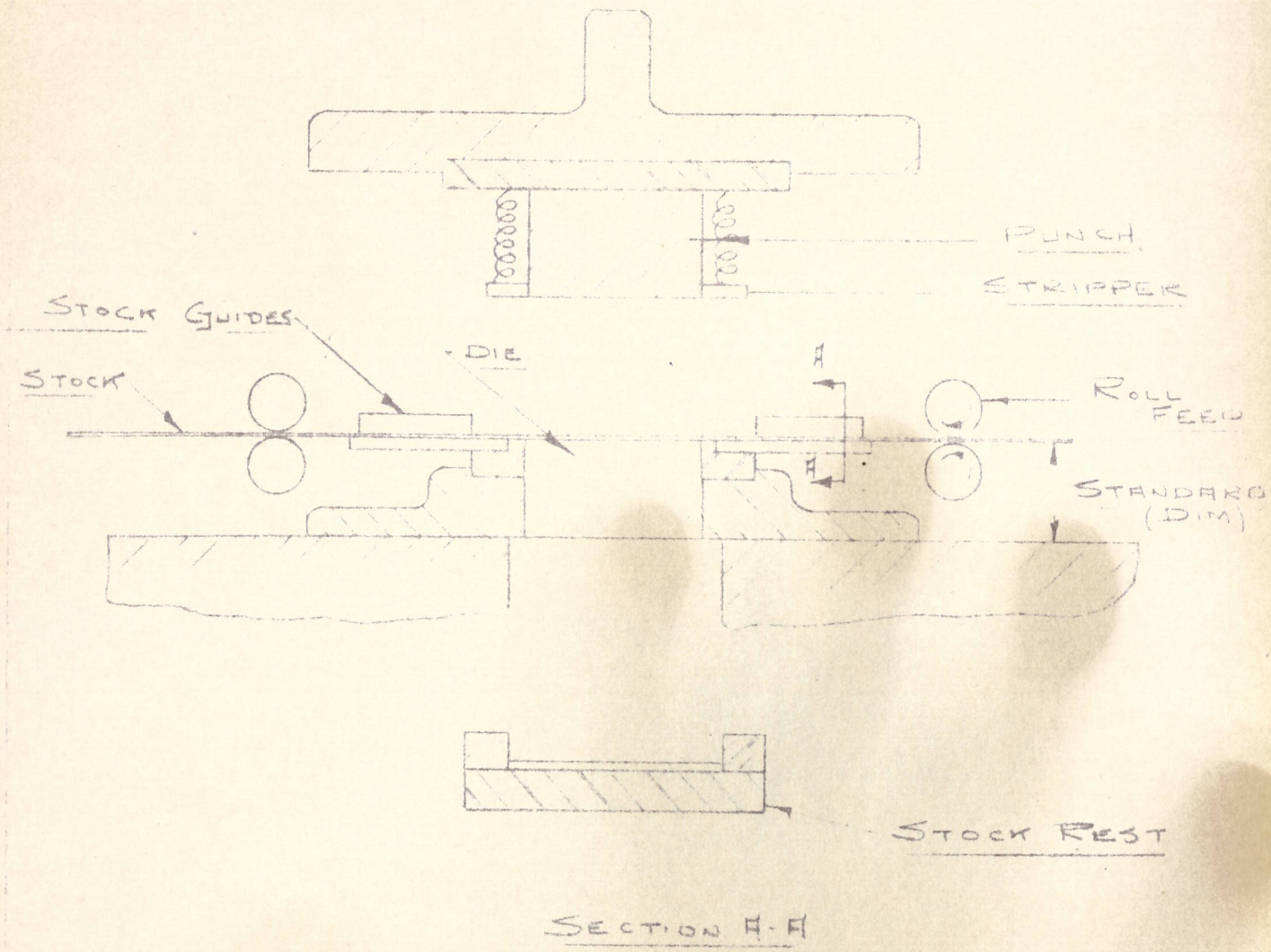
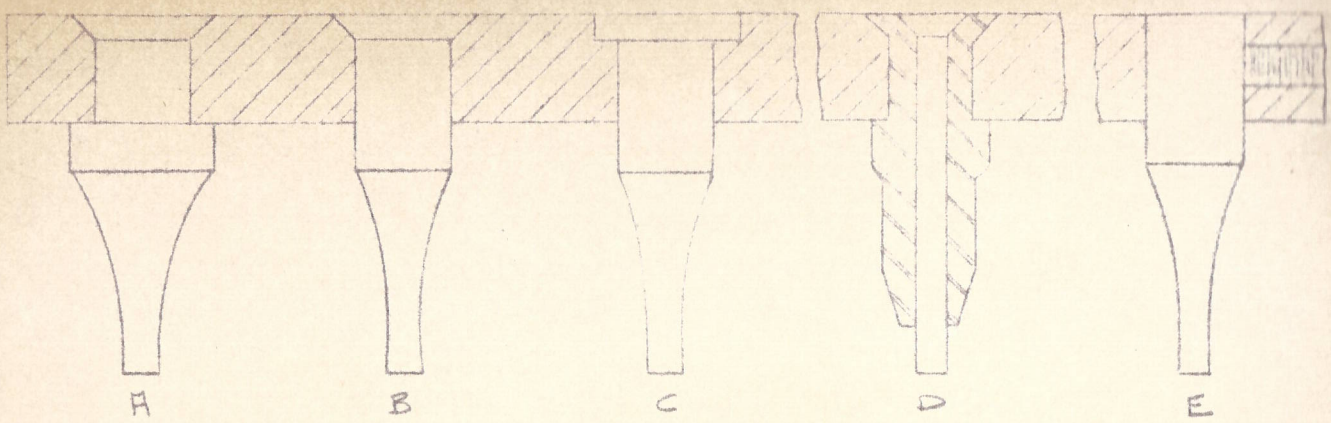


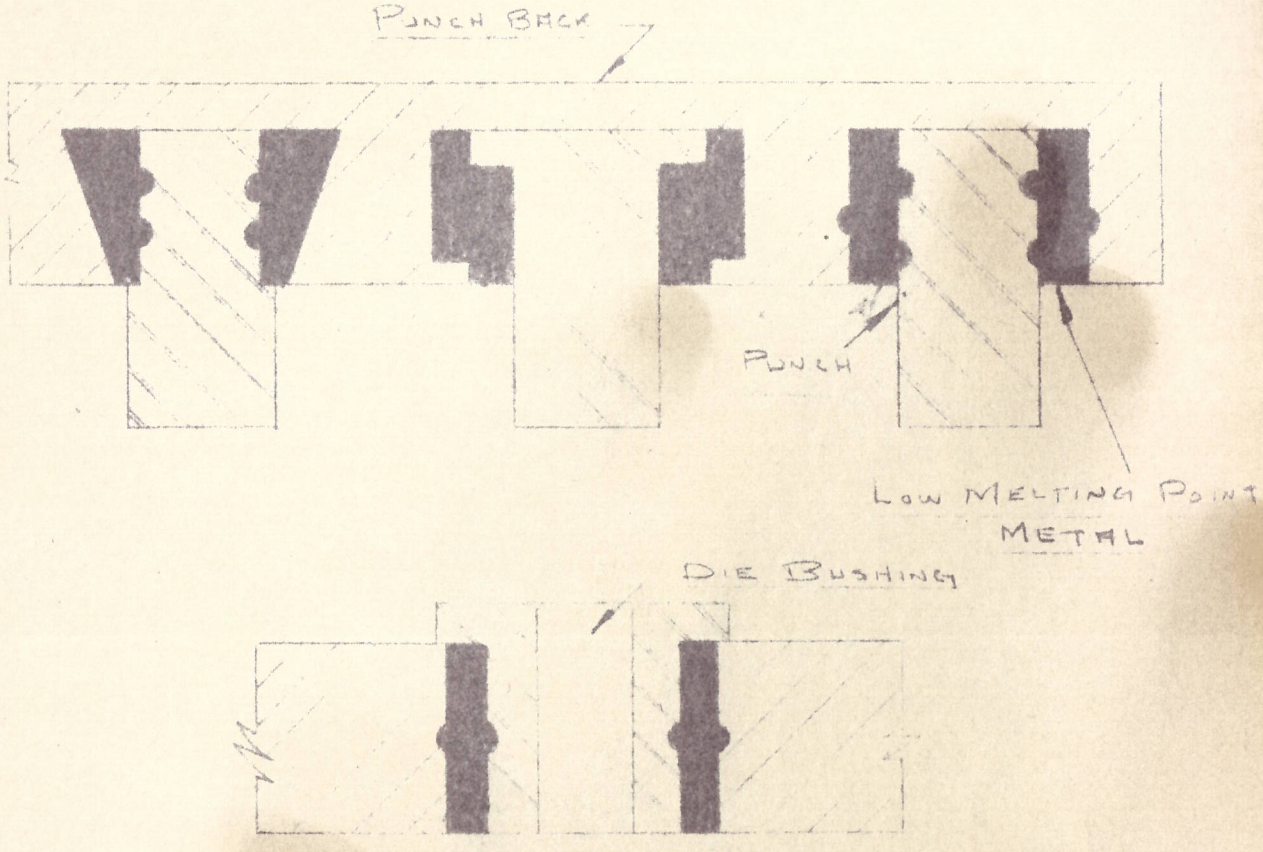
Fig 19



ROLL FEED SET UP FOR BLANKING OPERATION

FIG 20





METHODS OF HOLDING PUNCHES & DIE BUSHINGS

FIG 21

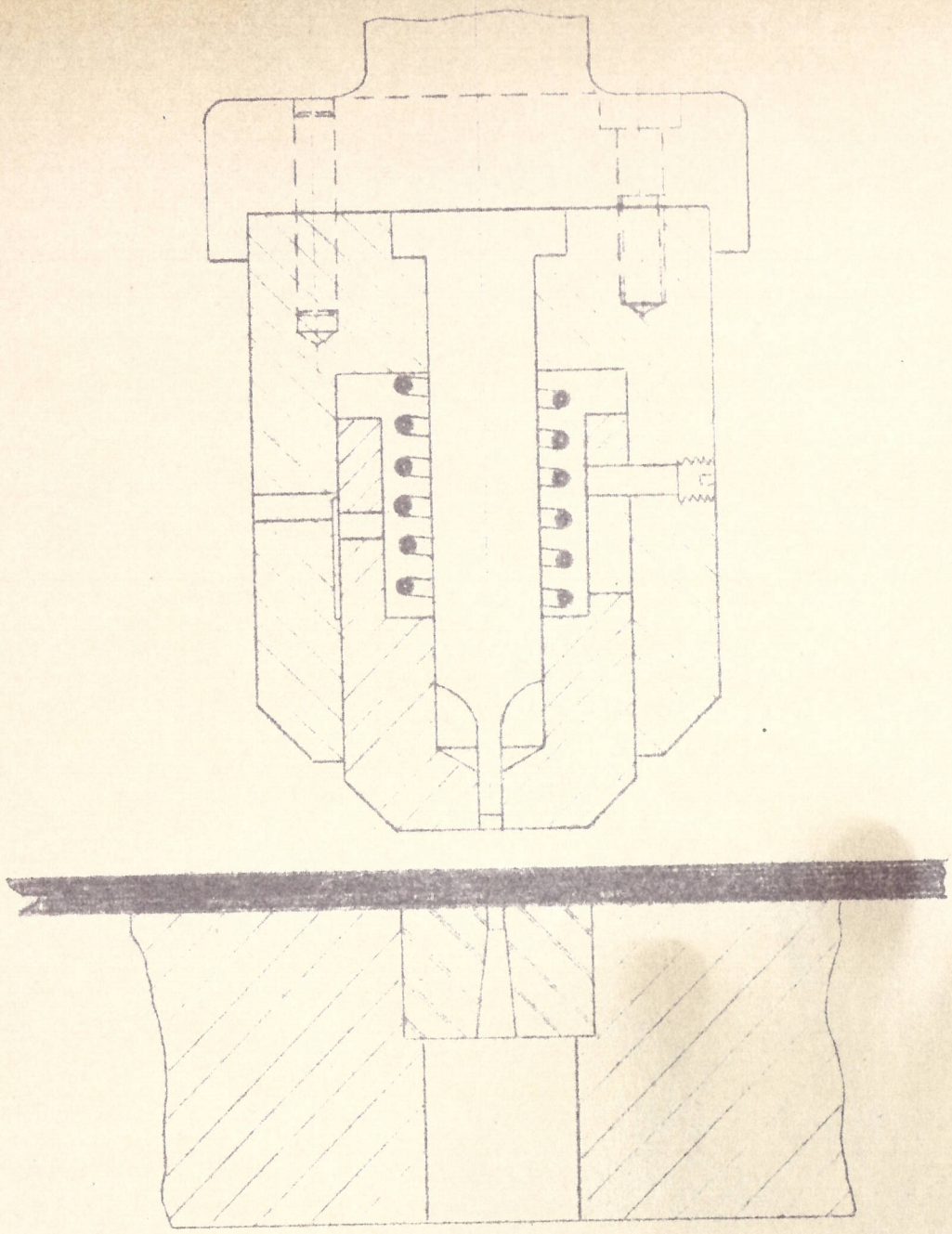
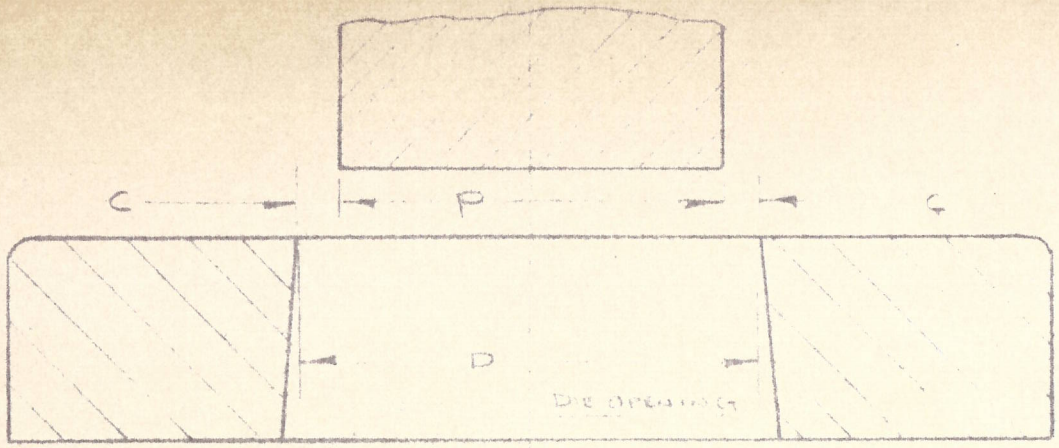


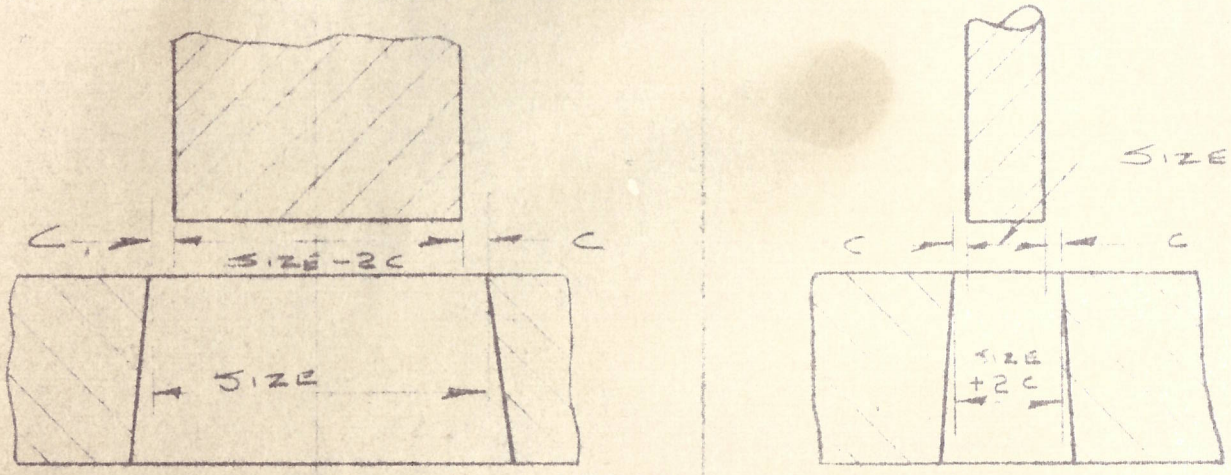
FIG 24



PUNCH SIZE = P
DIE SIZE = D
CLEARANCE = C
SIZE DIFFERENCE = D-P OR 2C

- DIAGRAM DEFINING CLEARANCE

FIG. 25

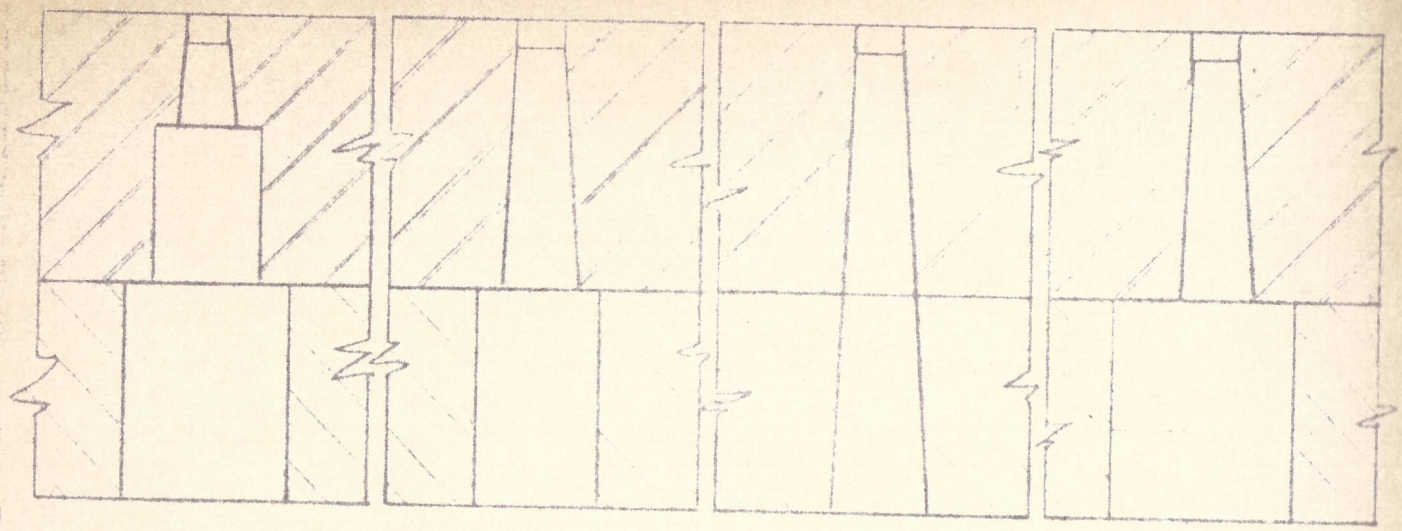


FOR BLANKS OF A GIVEN SIZE MAKE DIE TO SIZE, PUNCH SMALLER
A

FOR HOLES OF A GIVEN SIZE MAKE PUNCH TO SIZE, DIE LARGER
B

CLEARANCE ARRANGEMENT

FIG 26

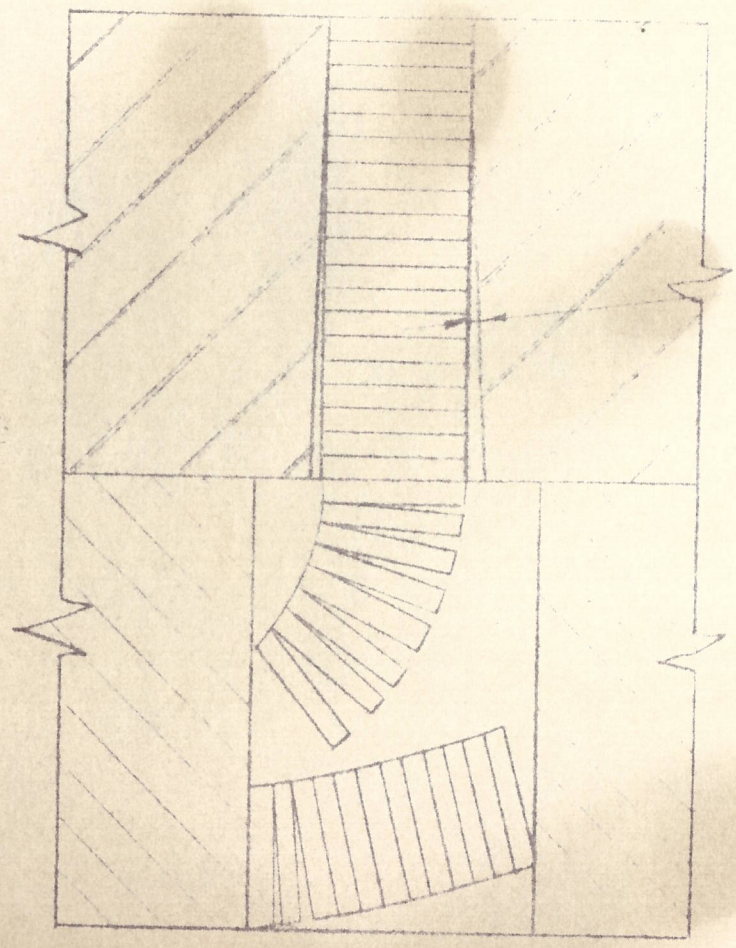


A
BAD

B
BAD

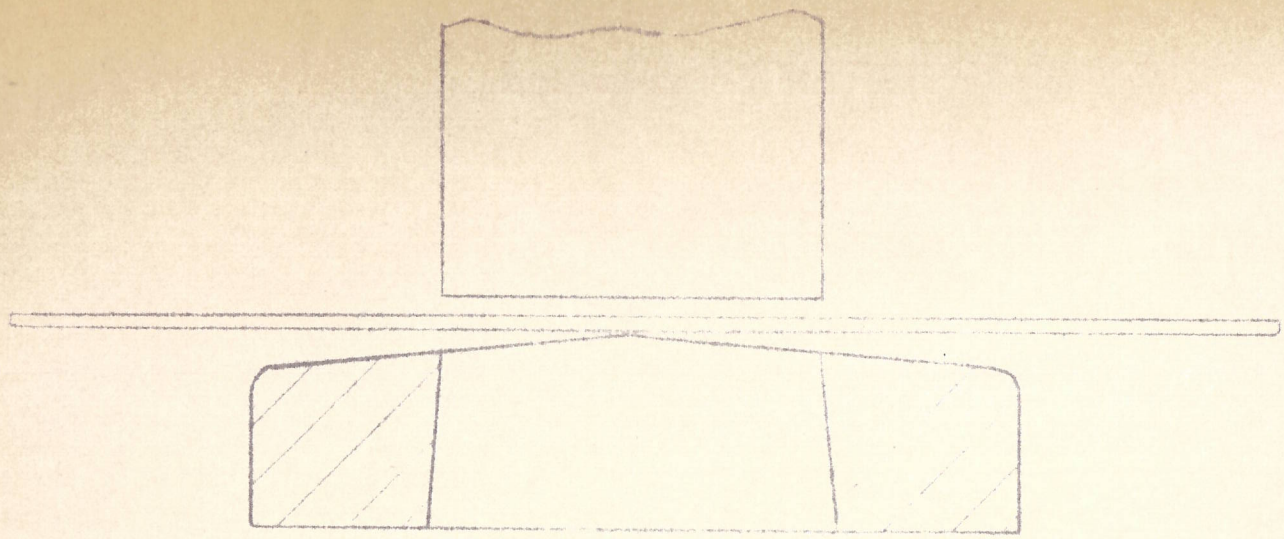
C
GOOD

D
GOOD



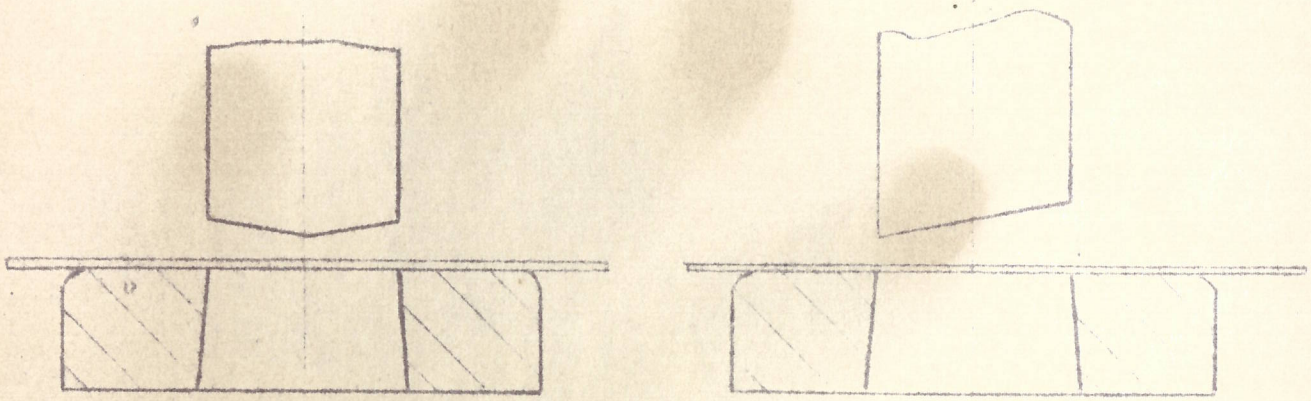
E
BAD

FIG 27



BLANKING DIE – 2-POINT SHEAR

BLANK WILL BE FLAT



2-POINT SHEAR

BALANCED

GOOD

1-POINT SHEAR

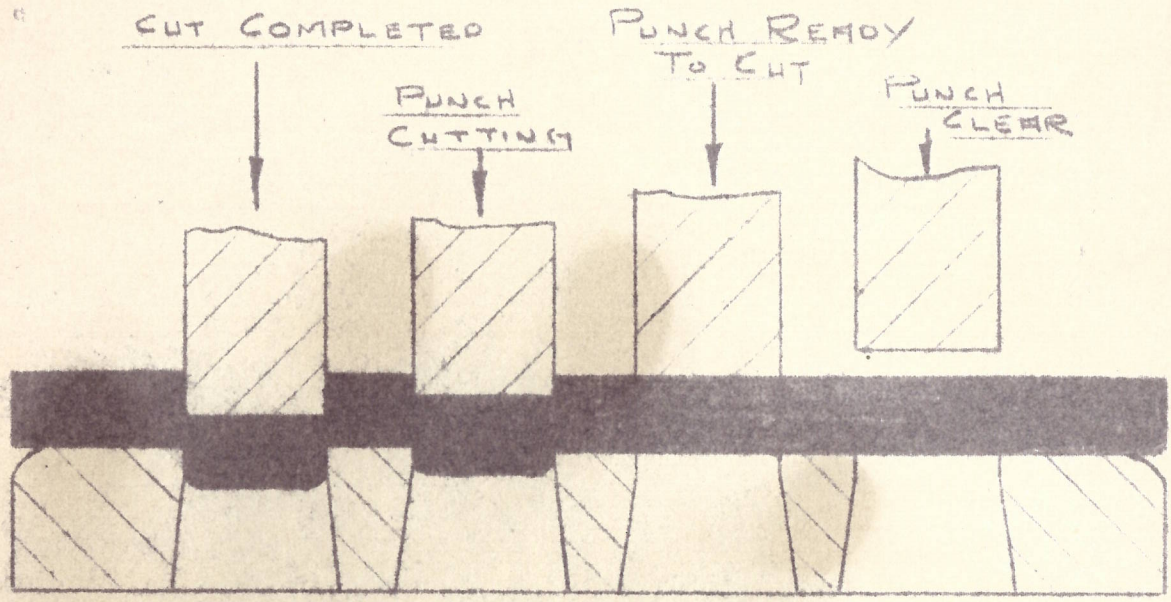
UNBALANCED

BAD

PIERCING PUNCH

STOCK WILL BE FLAT

FIG 28



FOUR PUNCHES VARY IN LENGTH BY AN AMOUNT EQUAL TO THE DEPTH OF PENETRATION

ONLY ONE PUNCH CUTTING AT ANY INSTANT

SMOOTH CUTTING ACTION WITH MINIMUM LOAD

STAGGER ON PUNCHES

FIG 29

DIE WORK

In cutting operation in dies the metal is stressed in shear between the approaching cutting edges of the tools until a fracture occurs.

The space between the cutting edge of the punch and that of the die is known as the clearance and should be proportioned to the thickness and temper of the metal being cut.

Clearance is defined as the space between the cutting edge of punch and die.

When the metal is stressed beyond its elastic limit the section area is reduced and fractures start at both upper and lower cutting edges where the load is concentrated. With further loading these fractures spread towards each other and when they meet the cut is complete.

Clearance between cutting edges determines the angle at which the fracture occurs. If these fractures do not meet, additional shearing will be necessary in order to cause separation.

(3) Characteristics of a Good Cut:

(a) Slight rounding of the surface along the top indicating the amount of of plastic deformation which has occurred.

(b) A burnished band indicating the depth of penetration by the punch before fractures start.

(c) A rough section below the cut band where the fracture occurred. See "C" Fig. 1.

The depth of penetration to effect shearing is usually greater for soft metals than for hard.

Tools without shear require maximum load conditions. The load required to make a given cut may be reduced by grinding shear on the tools and as the shear is increaded the load necessary to make the cut is decreased.

The limit to the amount of shear which can be given to a load is governed by the distortion of the stock and the skidding tendency which may bend the punches when the amount of shear is too great.

Constants C

Press Stroke in terms of shaft dia = D

a = Single crank, single drive - crank pin & bearings equal dia.

b = Single crank, single drive - oversize crank pin dia.

c = Single crank, double drive - oversize crank pin dia.

d = Double crank, single drive - oversize crank pin dia.

e = Double crank, double drive - oversize crank pin dia.

Type of Crank	.25D	1 D	1.5 D	2 D	2.5 D	3 D
a	-	2.8	2.3	1.8	-	-
b	4.5	3.5	2.7	2.2	1.8	1.6
c	-	5.0	4.2	3.5	3.0	2.7
d	5.4	4.4	3.2	2.5	2.2	1.7
e	-	-	5.4	4.4	3.7	3.2

Multiple or Gang Dies are those which cut 2 or more blanks at each stroke of the press.

Progressive or Follow Dies are those which include two or more work stations, each performing a different operation. The stock is moved one station at a time.

Compound or Blank & Pierce Dies perform more than one operation at one station in one stroke, the work being left on the die.

The principal function of guide pins is to keep the two cutting edges in alignment during the cutting cycle in order to maintain a uniform clearance all around the periphery.

Tendency of the metal being cut to curl up much when it is necessary to sand most cutting tools to be quite sharper. The pressure required to strip the metal from the punch may be as high as 10 - 15 % of the cutting pressure.

On Die Design sheet weight shall be given as Max. & Min.

Blanking Pressure Formula

#1. P = Maximum Pressure
L = Length of cut
t = Thickness of Stock (ins.)
Ss = Shear strength of metal p.s.i.
P max. = L x t x Ss

Actual pressure required may be less, [illegible] will be [illegible] of penetration of punch. For safety [illegible]

% Penetration of Punch:

Soft Alum.	--	54 %	
Soft Brass-Hard Alum	--	25 %	Not [illegible]
Low Carbon Steel	--	30 %	
R.C.S.	--	16 %	and Pro. Alumes.
Hard Steel	--	8%	

#2

Actual Pressure Formula - P = L x t x [illegible]

#3

Work Done:

W = Work done in inch tons
t x % Pen. = Working Distance
1.16 = Allowance for L/C Friction
W = P max. x t x % Pen x 1.16

#4 Flywheel Energy

E = Flywheel Energy (inch tons)
D = Flywheel Dia. in feet
W = Wt. in tons of flywheel

$$E = \frac{RPM^2 \times D^2 \times W}{18,200}$$

#5 P = Press Capacity in tons
C = Constant (see below) next page
= [illegible]

CLEARANCES

The clearance in a press cutting tool isdefined as the space between the cutting edges at any point when the punch is centrally located in the die.

The difference between the size of the punch and the die opening is known as the "Size Differences".

METAL	SOFT	MEDIUM	HARD	
Alum.	10%	12 %	13 %	
copper	6 %	7 %	8 %	% of
Brass	5 %	6 %	7 %	Metal
Steel	4 %	5 %	6 %	Thickness.
Magnesium		2-1/2 %		

DIE RELIEF- Fig 27.

Is intended to provide rake to the cutting edges of the die and to facilitate removal of punchings. For average work on the softer metals this relief stops at the cutting edge and for accurate word on the harder metals the die opening is made parallel for about 1/16 or more and then relieved from the lower edge of this parallel band.

On small punches 1/2° to 1°

SHEAR AND STAGGER-Fig 28and 29.

If the sheet to be cut must be flat the die is made flat and the shear ground on the punch. If the pieces cut out must be ground on the die.

SHAVING

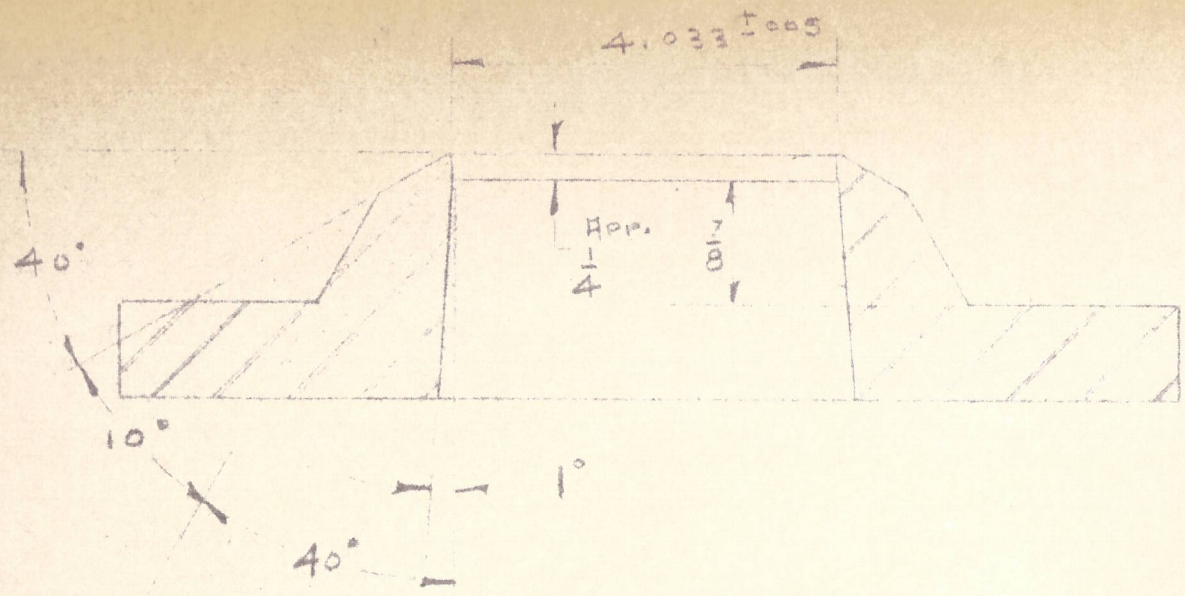
1 stage shaving 8 to 12 % of metal thickness.
2 stage shaving 6 to 12 % for 1 st. stage.
3 to 6 % for 2nd. stage.

Amount shown below should be added to metal for shaving all around.

STOCK THICKNESS	SOFT STEEL	MED. STEEL	SOFT BRASS	MED. HARD BRASS
.047	.0025	.003	.005	.006
.063	.003	.004	.0055	.007
.078	.0035	.005	.006	.008
.094	.004	.006	.0065	.009
.109	.005	.007	.007	.010
.125	.006	.008	.0075	.011

Shaving punch should not enter die or if necessary clearance between punch and die should be next to zero.

DIE FOR BLANKING 1" ALUMINUM 4 DIA



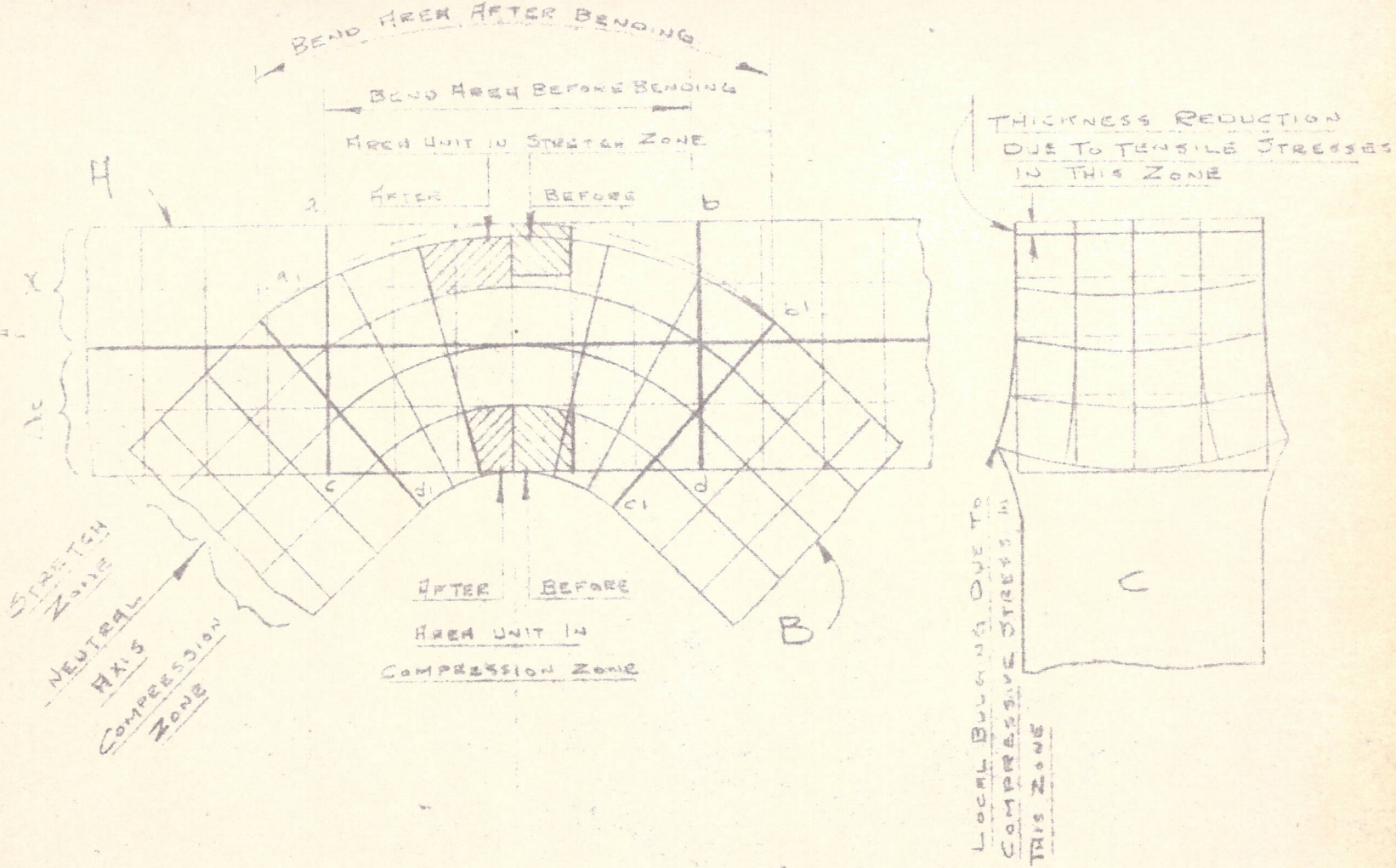
EDGE DISTANCE ON AVERAGE BLANKING DIE = 2 to 3 X Gauge.

When punches are numerous and slender, harden and grind stripper plate to act as guide for punches, using guide pins into the punch holder if necessary to keep stripper plate true. Use tool steel plate to back up punches if diameter is extremely small.

Make big punches out before small punches when variation in punche sizes is great in the die.

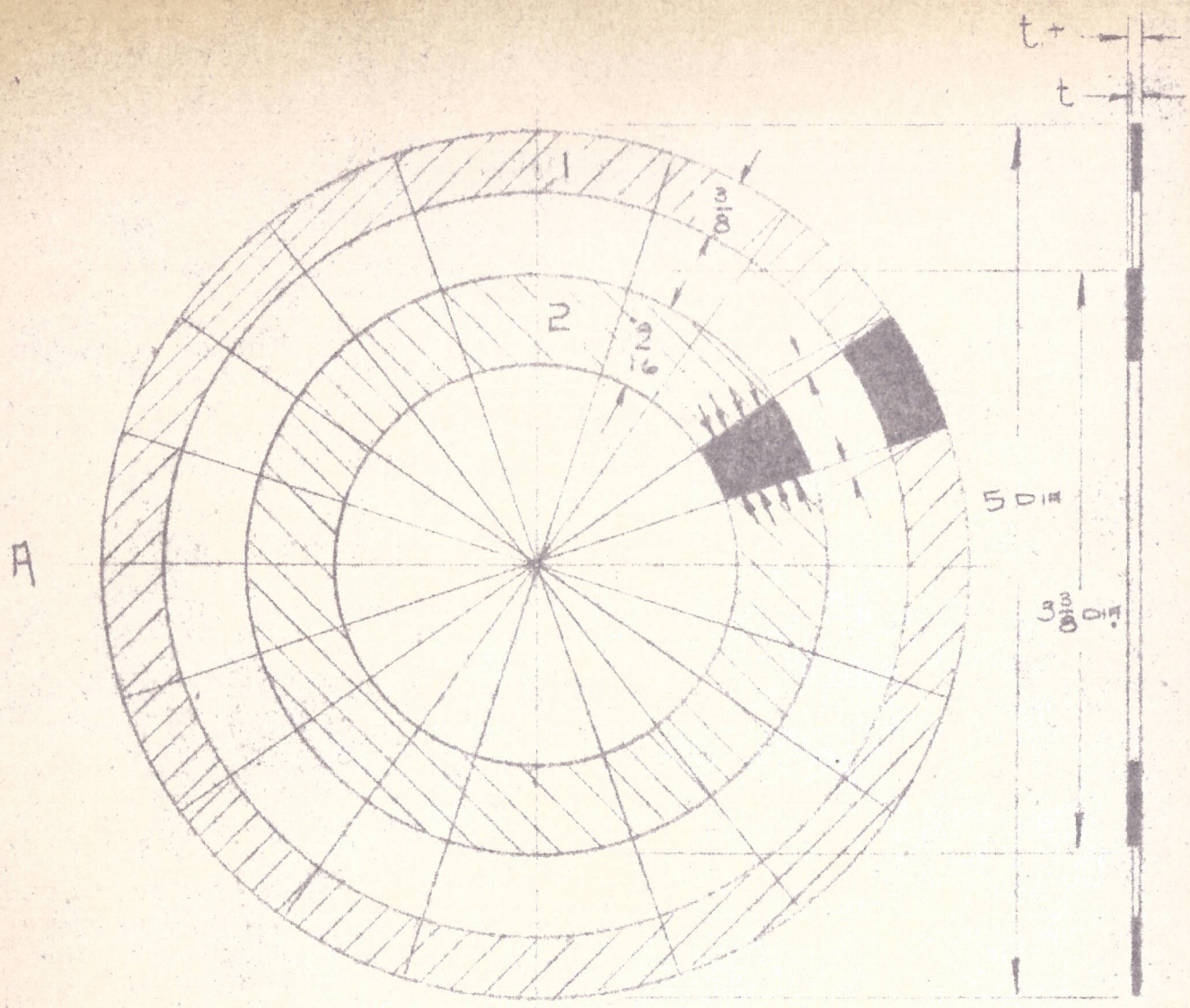
Clearance between punch and die on drawing operations

= Metal thickness + 8 to 10 % of Gauge.



METAL MOVEMENT IN A BEND

FIG. 1


t+
t
1
2
3/8
2/16
5 DIA
3 3/8 DIA
A

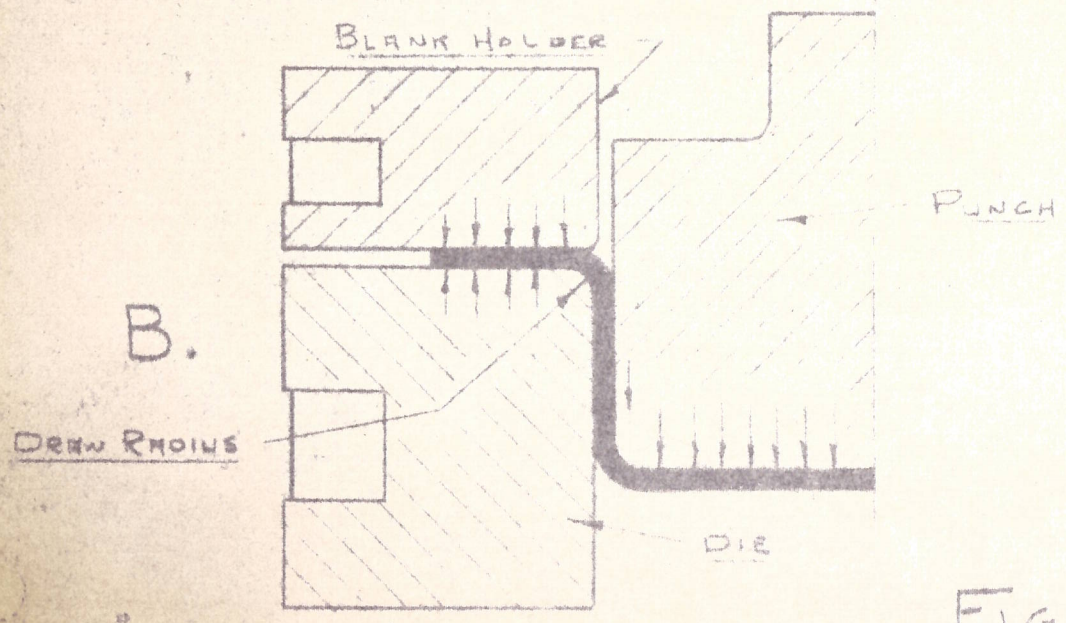

BLANK HOLDER
PUNCH
B.
DRAW RADIUS
DIE

FIG. 2

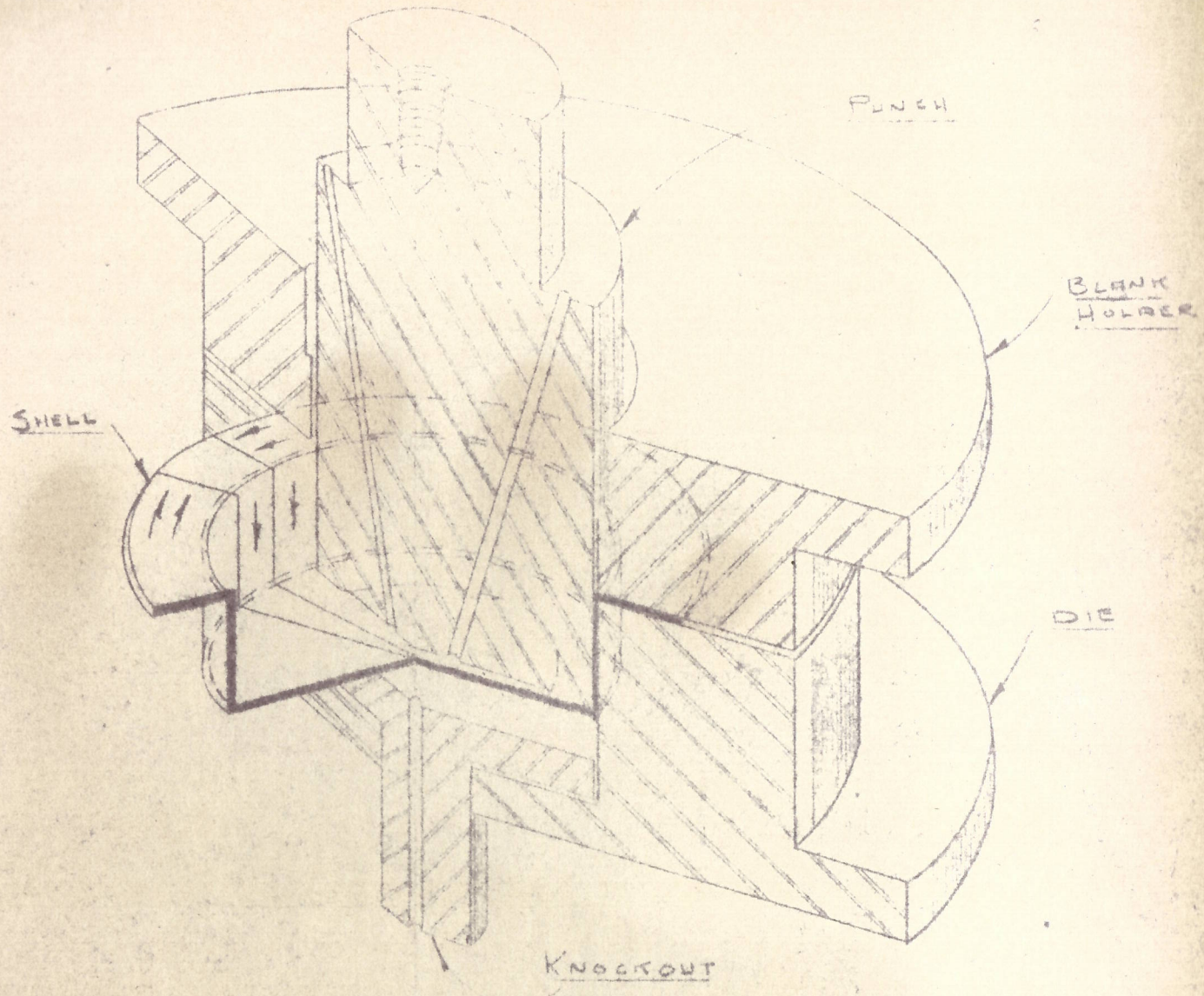


FIG 3

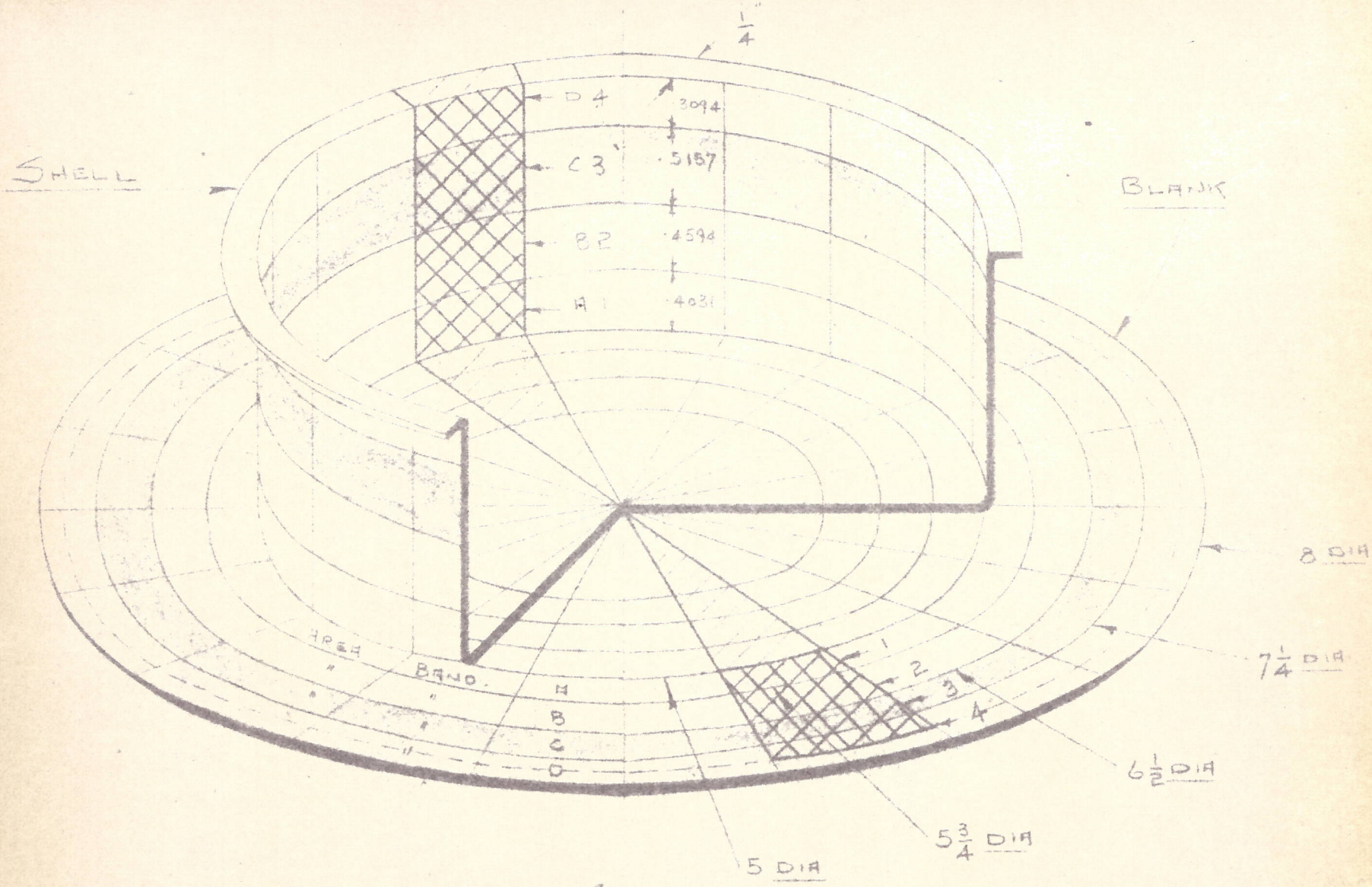
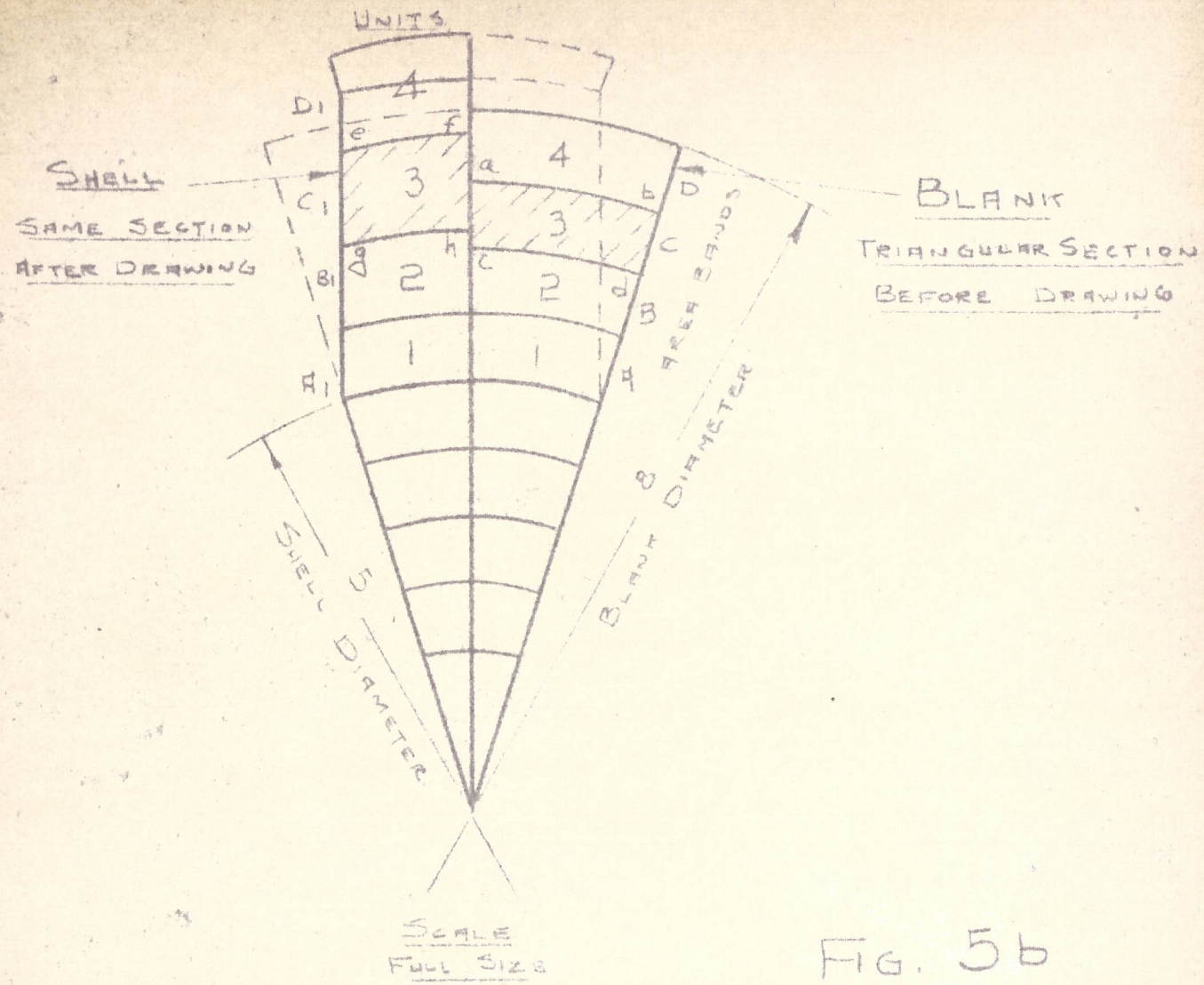

1/4"
D 4
C 3
B 2
A 1
·3094
·5157
·4594
·4031
SHELL
BLANK
8 DIA
7 1/4 DIA
6 1/2 DIA
5 3/4 DIA
5 DIA
AREA
BAND
A
B
C
D
1
2
3
4

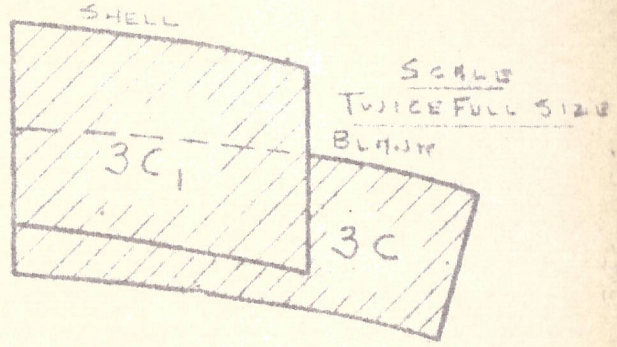
FIG 4

FIG. 5a



AREA OF UNITS WILL REDUCE APP. 5% ON BEING DRAWN INTO SHELL DUE TO THICKENING OF GAUGE SLIGHTLY

FIG. 5b

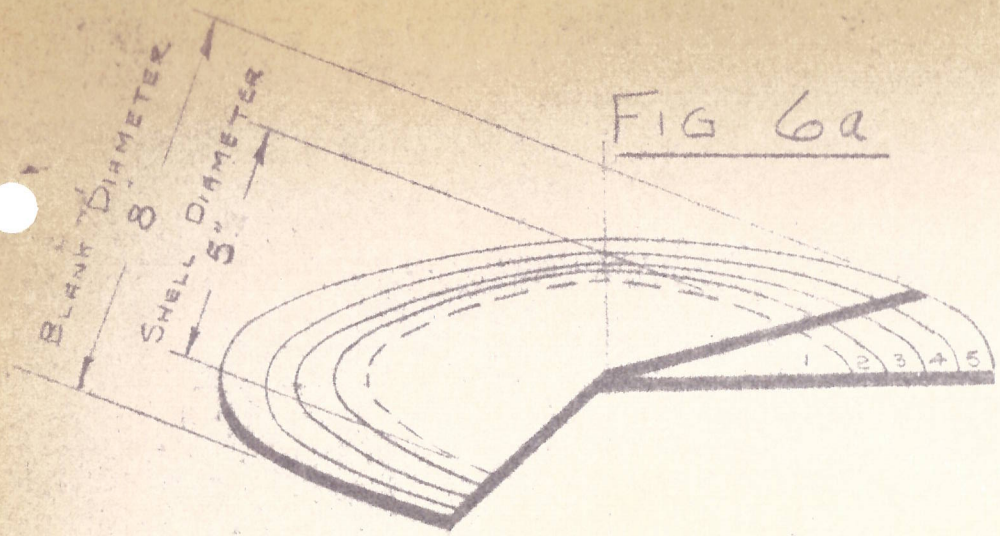


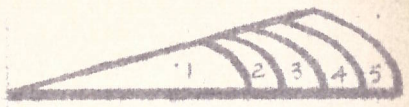
RELATIVE SHAPE AND POSITION OF ONE AREA UNIT, BEFORE & AFTER DRAWING

METAL FLOW IN A TYPICAL GROUP OF AREA UNITS DURING THE DRAWING OF A CIRCULAR MARKED WITH CONCENTRIC CIRCLES

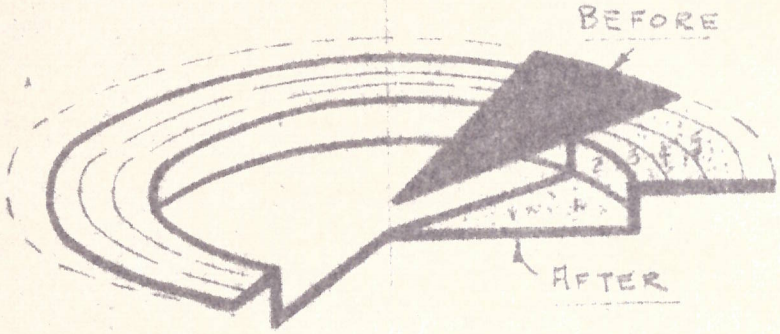
FIG 6a

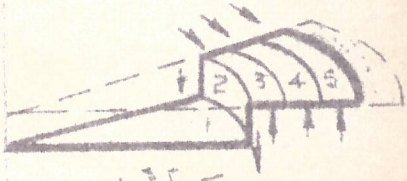
FIG 6b



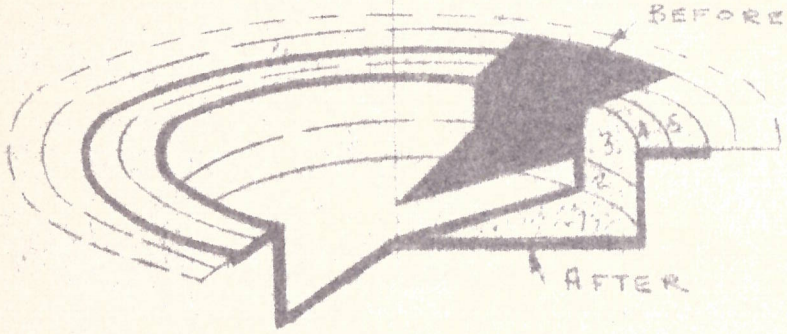


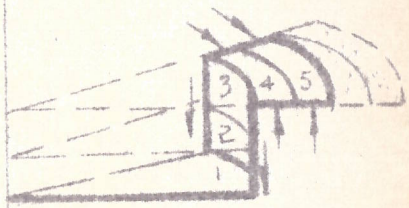
BLANK SECTION



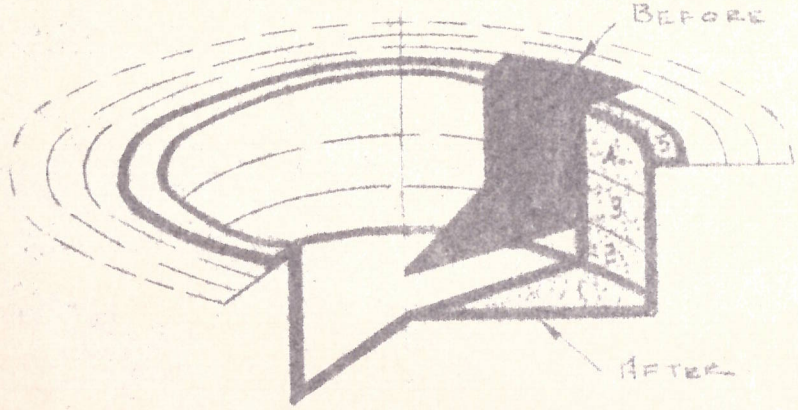


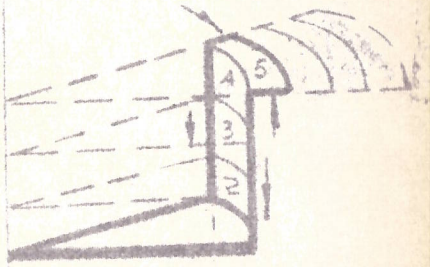
1ST STEP





2ND STEP





3RD STEP

METAL FLOW. STEP BY STEP

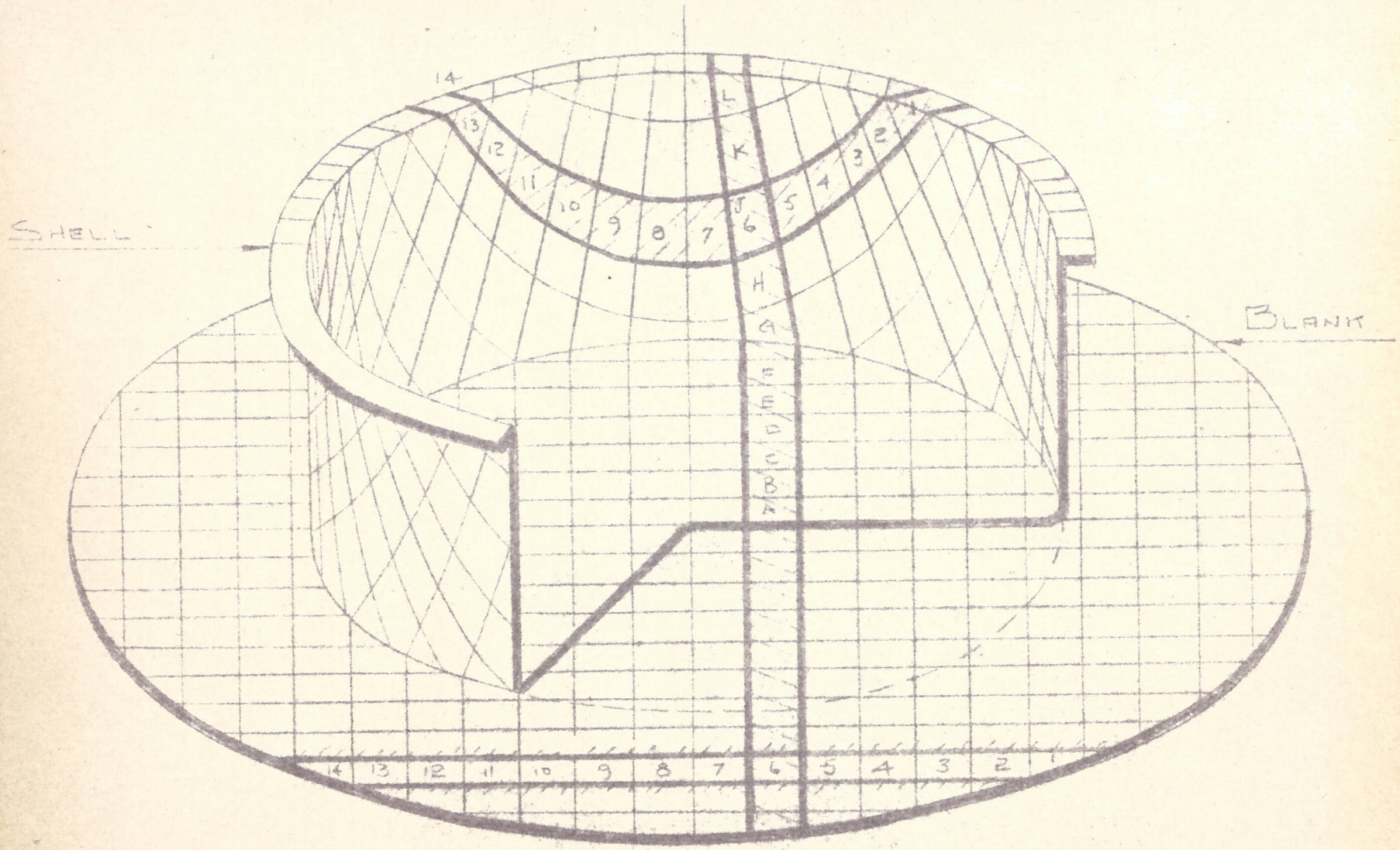


FIG. 7.

FIG 8

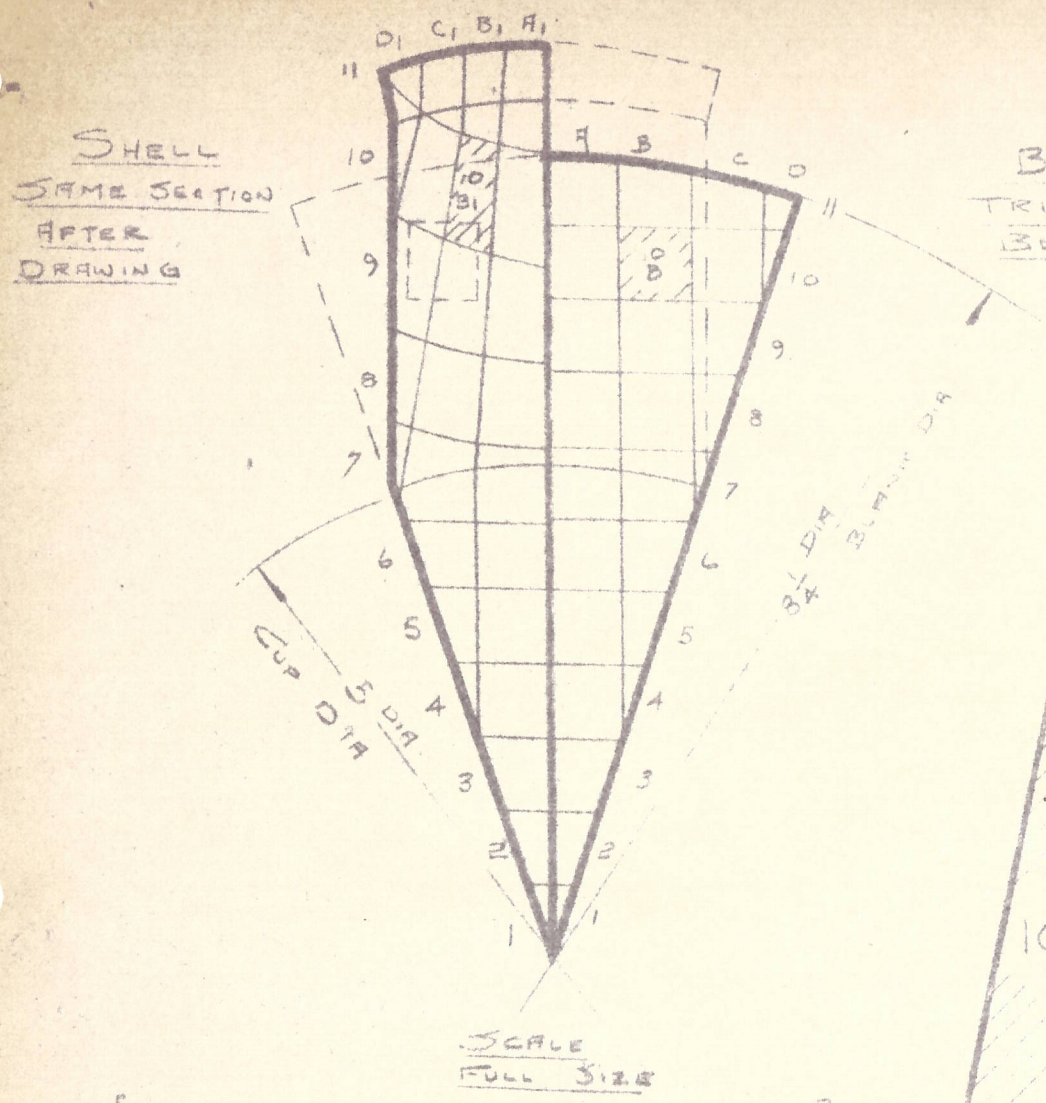
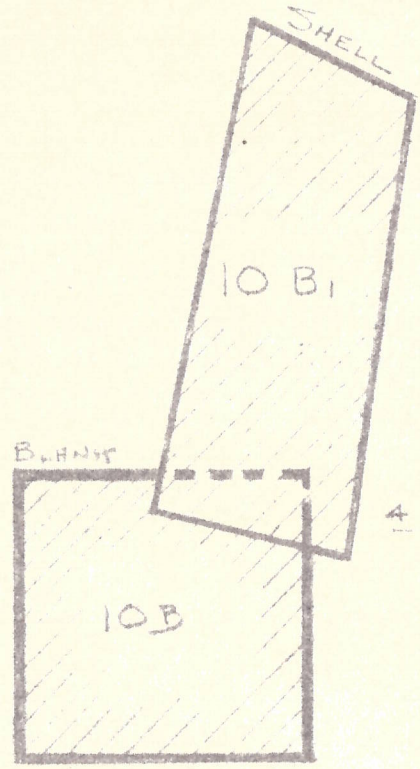


FIG 9



SCALE
4 TIMES FULL SIZE

RELATIVE SHAPE & POSITION OF ONE AREA UNIT, BEFORE & AFTER DRAWING

METAL FLOW IN A TYPICAL GROUP OF AREA UNITS DURING THE DRAWING OF A CIRCULAR SHELL MARKED WITH SQUARES

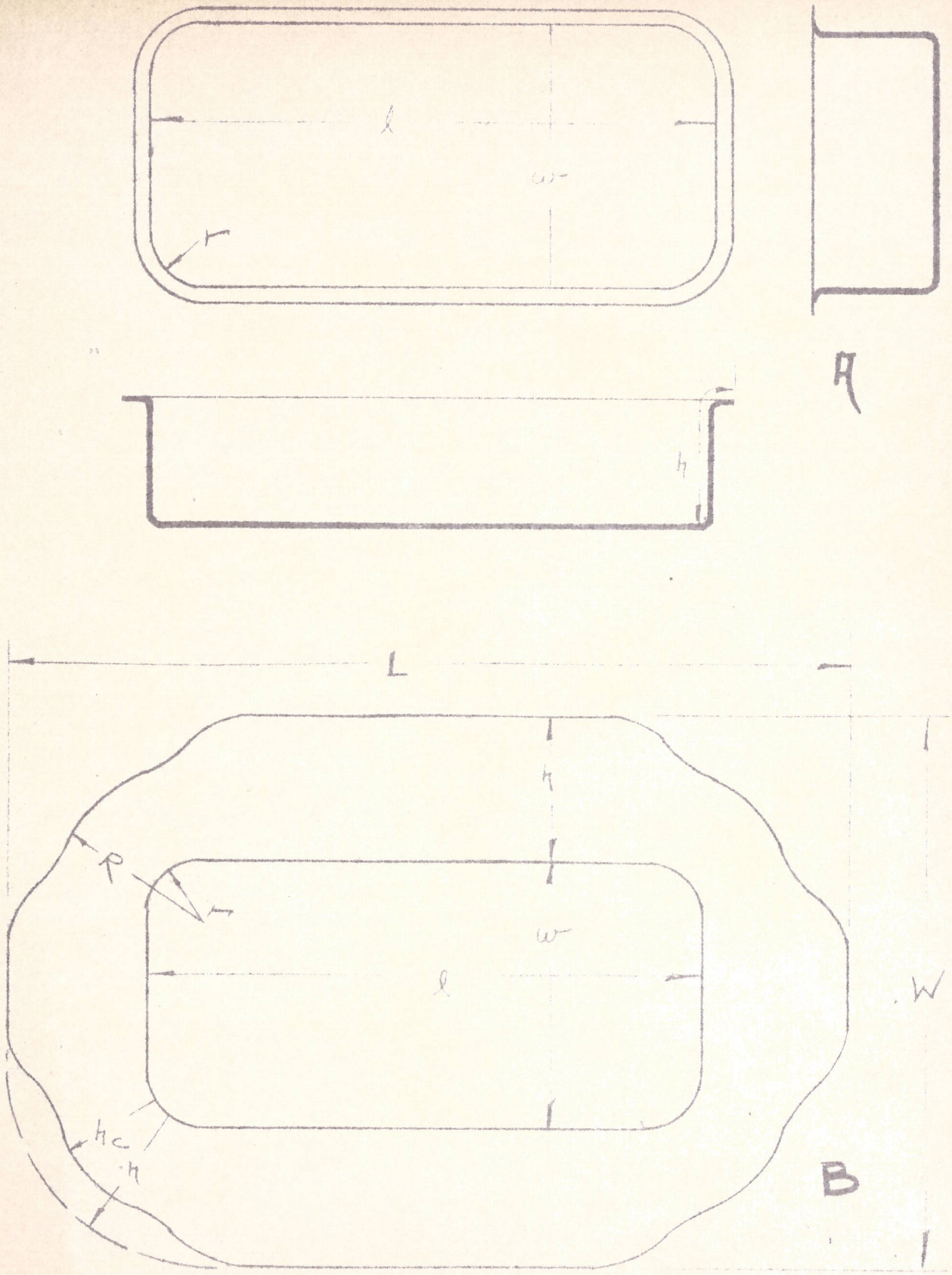


FIG. 10.

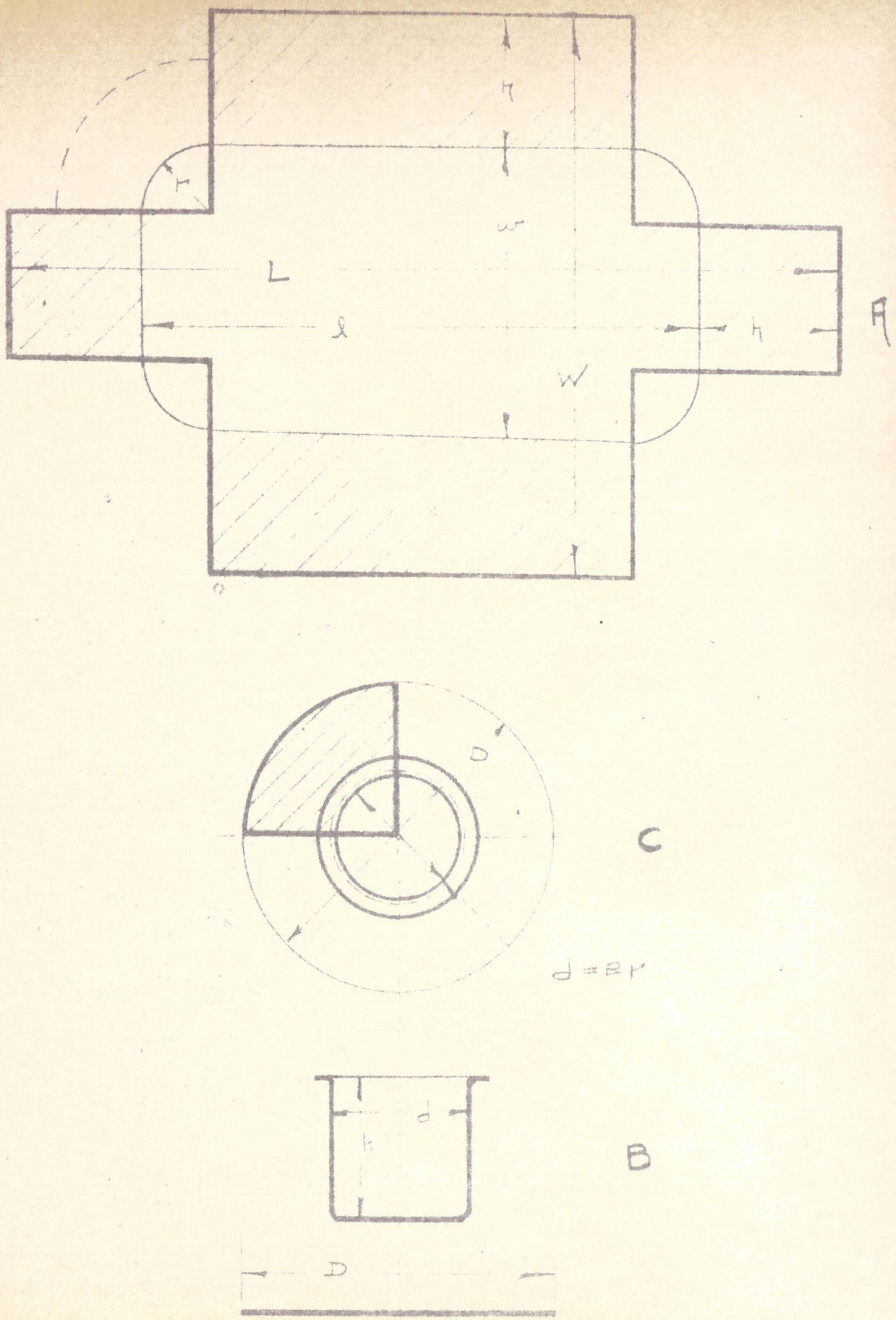


FIG. 11

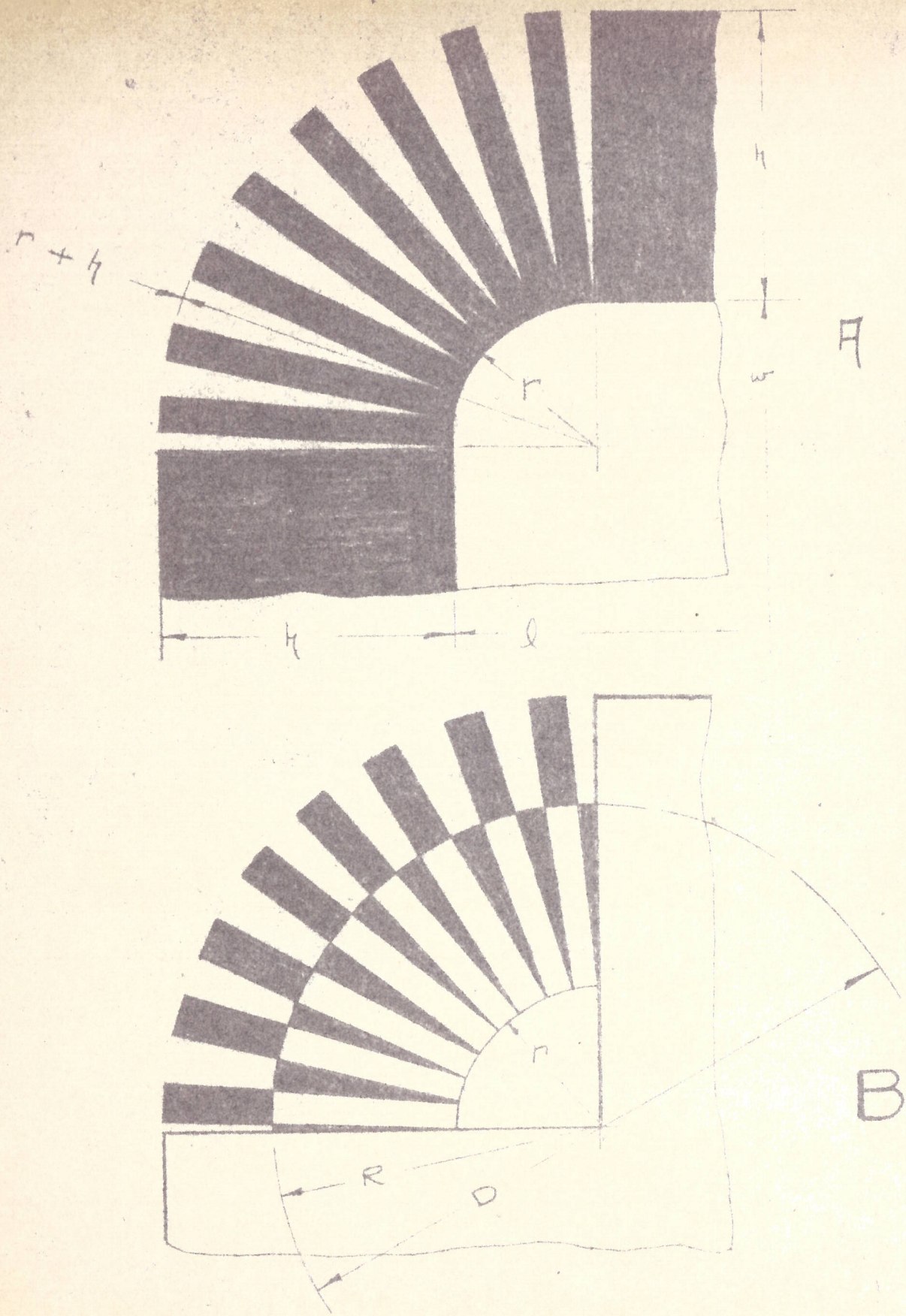


FIG. 12

MAGNESIUM:

(1)	Mineral Oil	95%	(Ice Hot)
	Fish Oil	5%	600° F

Any lubricant containing sulphur will blacken brass and attack nickel alloys.

Lubricants containing alkali react chemically with zinc and if work is allowed to stand with alkaline lubricant on it, the surface becomes roughened and more difficult to draw.

LUBRICANT: For Coated or Lithographed Work:

(1)	Paraffin Wax	60%
	Fine Oil (light)	40%

(2) Liquid Gloss Finish (Atlantic Refining Co.)

(3) Seal Drawing Oil (Imperial Oil Co.)

PERFORATED ALUM. WORK: (Salt & Pepper Shaker Caps)

(1) Alcohol.

SCRATCH BRUSH FINISHED WORK:

(1)	Alcohol	95%
	Castor Oil	5%

WEIGHT METHOD OF CALCULATING BLANK DIA.

$$D = 1.128 \sqrt{\frac{W}{w\,t}}$$

D = Blank Dia. in inches.

W = Weight of Shell.

w = Weight per cu. inch.

t = Thickness of Blank.

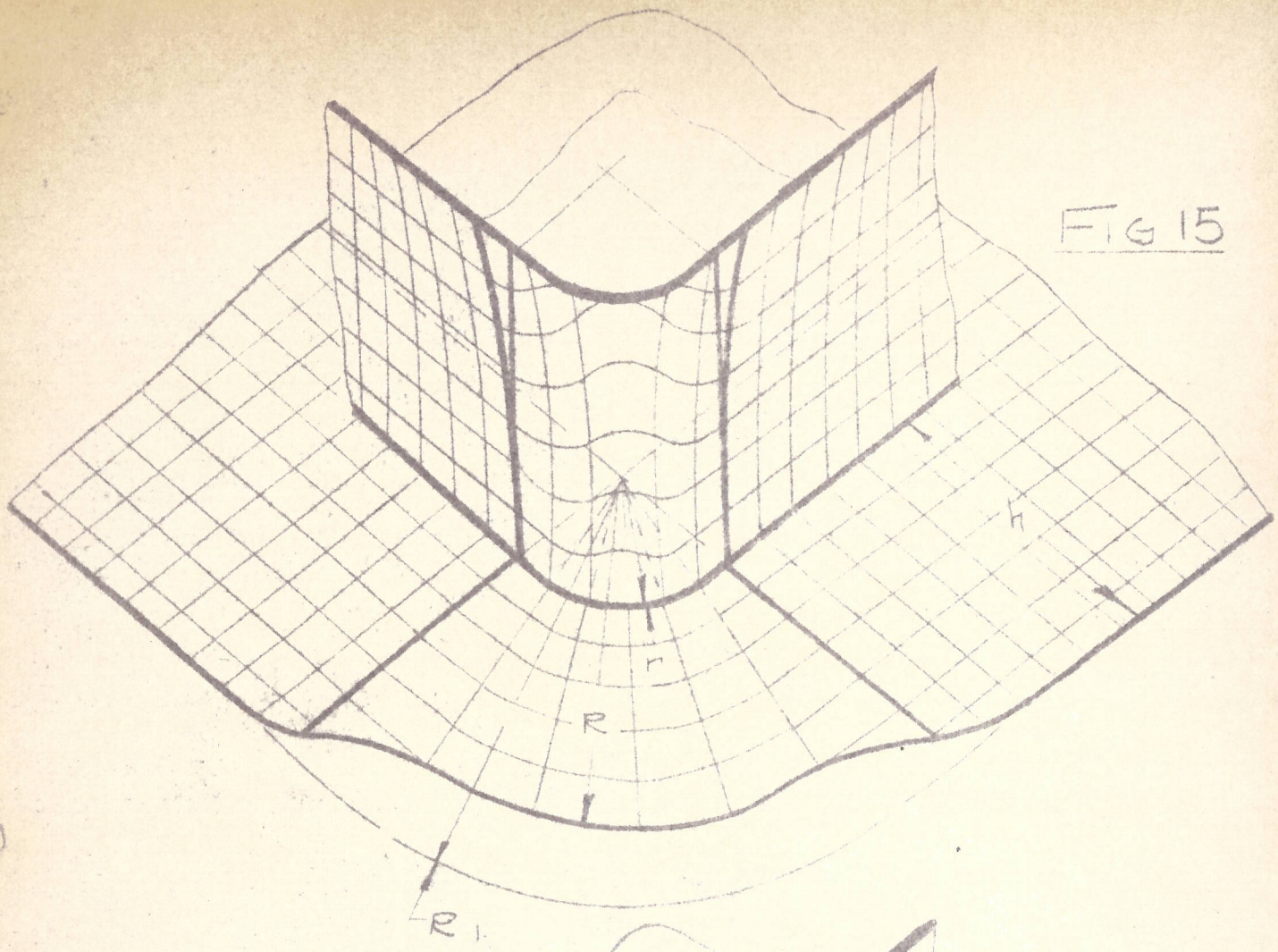


FIG 15

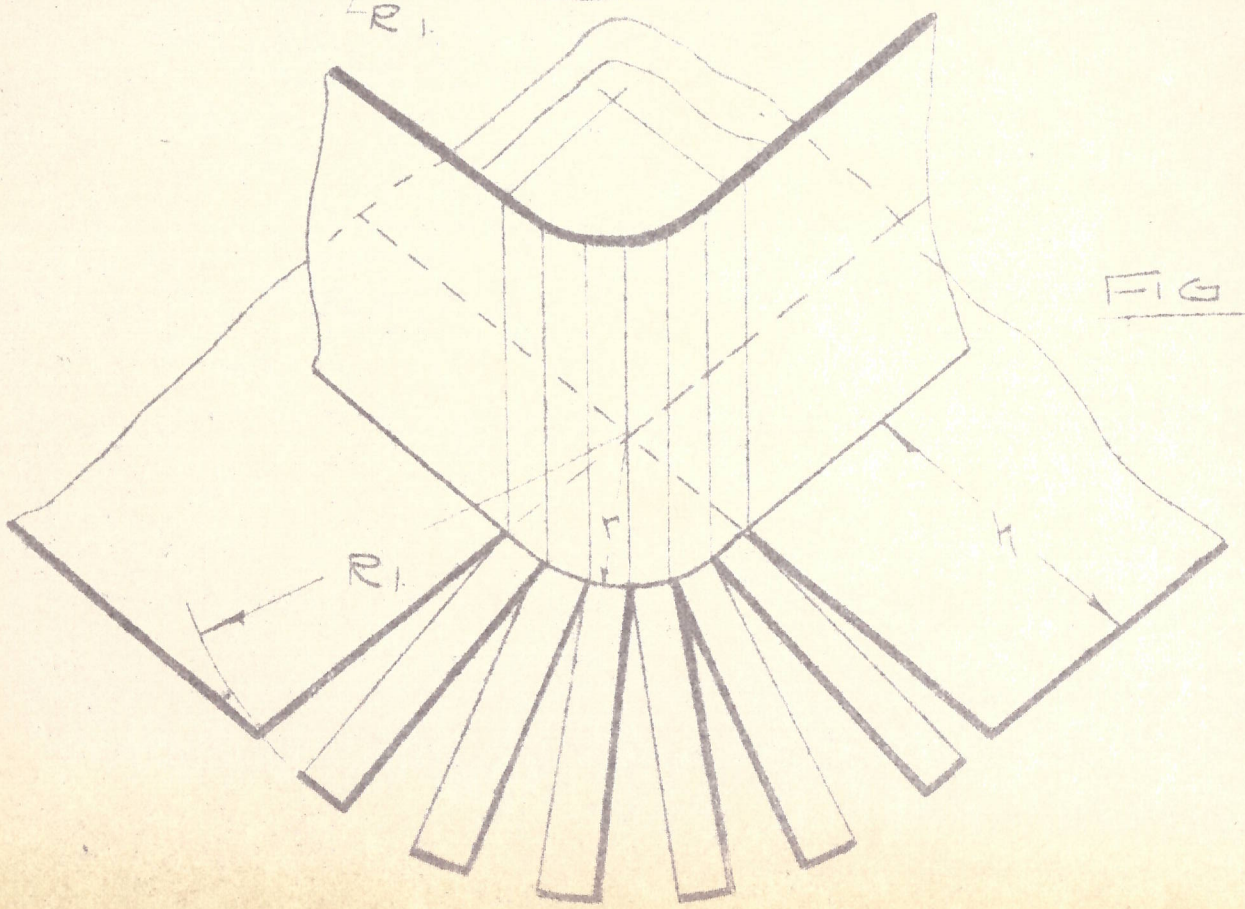


FIG 16

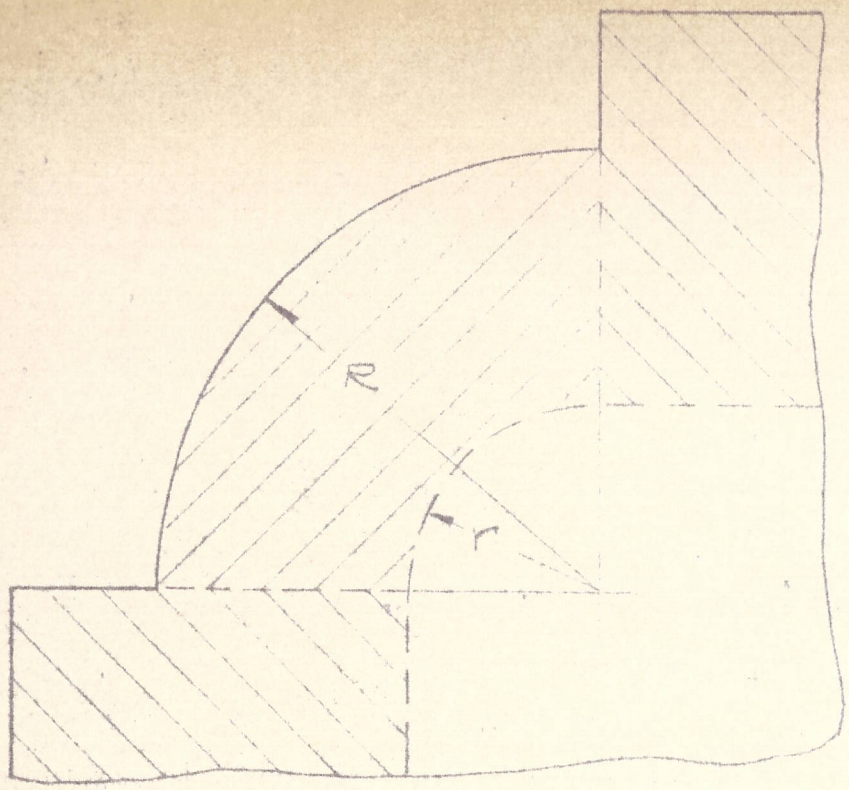


FIG 13

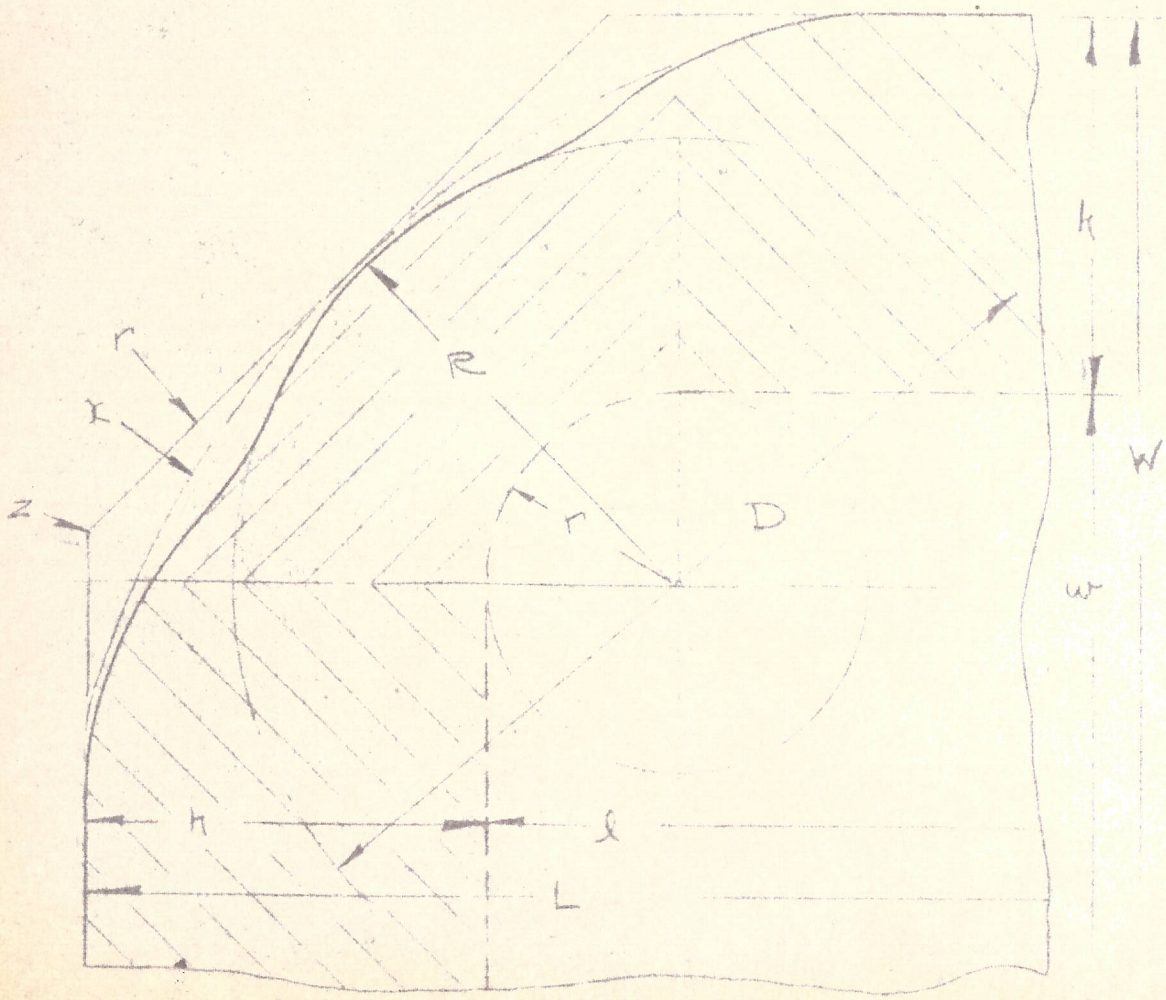


FIG 14

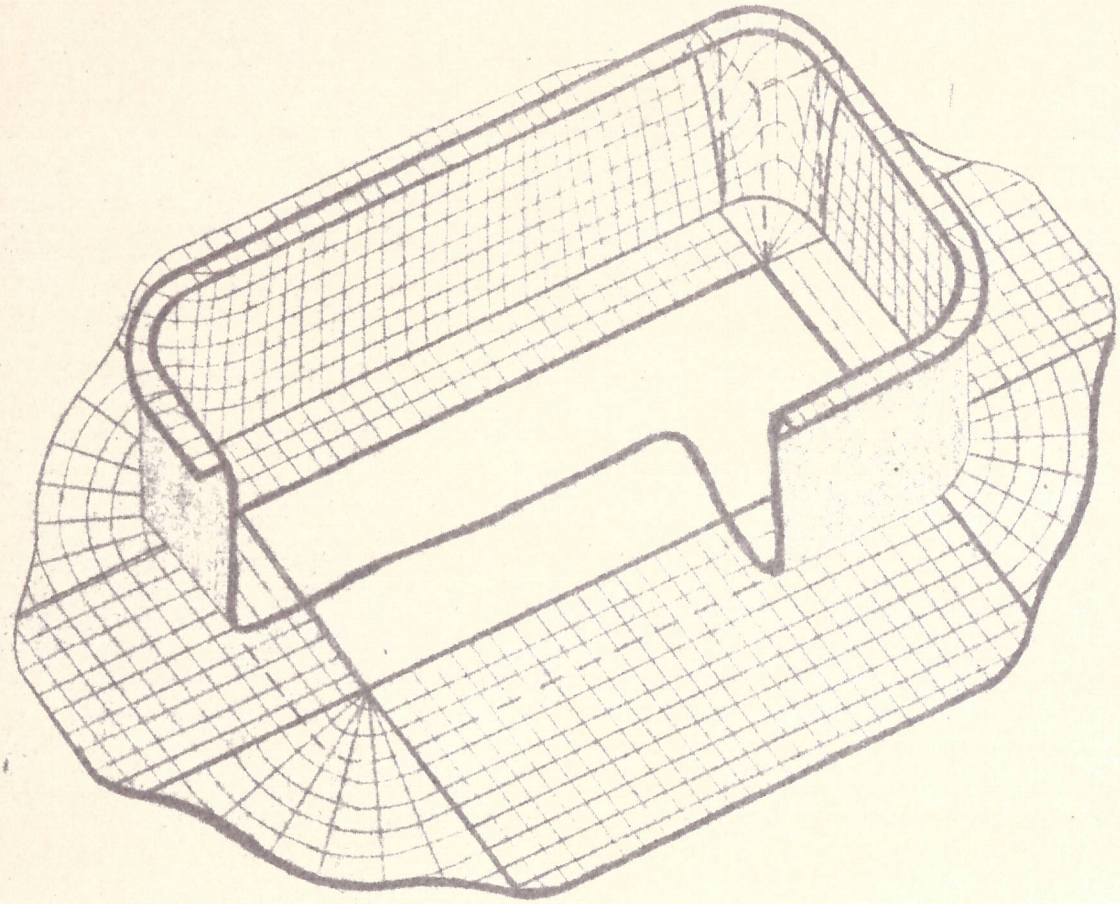


FIG 17

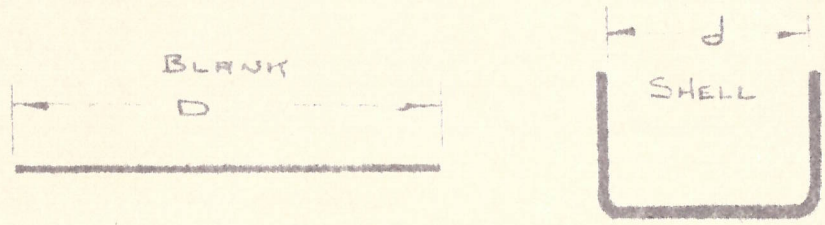
DRAWING

Blank Dia:should not exceed 1.8 (for Shell Dia. - first draw)

The reduction in diameter must be such that the area under compressive stress is reasonably proportioned to the area under tensile stress.

When the ratio of blank to shell diameter $\frac{D}{d}$ is too high, the drawing pressure will exceed the strength of the shell. This ratio should rarely exceed 1.8 because the greater the area being made to flow, the greater will be the compressive stresses in the flange area, and in consequence, greater pressure will be required to make the metal flow.

1.8 ratio gives about 48% reduction in diam.



(See Fig. 4)

Before drawing units #1 - 2 - 3 & 4 gradually increases in length as they approach the outside of the blank and they are all equal in width. After drawing they become a column of units of equal length but varying width - the width being equal to the length of the arc at the shell diameter (5" in this case). That part of the blank within the 5" diameter circle will not change at all because there is not metal movement in that area.

The resistance to flow in the flange area determines the amount of the tensile stress in the side walls. The greater the difference between the shell and the blank dia., the greater will be the area which must be made to flow, and in consequence the higher the tensile stress must be in the side walls to make it flow.

Also the higher the compressive resistance of the metal to cold working, the higher must be the tensile stress in the side walls.

45% reduction in drawing 2S0 aluminum will change the material from dead soft to 3/4 Hard in one draw.

In cutting operations the pressure to effect shearing must exceed the shear strength of the metal. In drawing operations the pressure must lie between the yield point and the ultimate strength. The drawing pressure must exceed the yield point in order to permanently change the shape of the metal, but it must not exceed the ultimate strength of the material or tearing will result.

The range between these two points is known as the plastic range. This range is reduced by cold working because as the draw proceeds the yield strength of the metal rises more rapidly than the ultimate strength, resulting in a definite narrowing of the plastic range and a decided decrease in plasticity.

The percentage reduction of blank to shell is expressed by the formula $\frac{D-d}{D}$ where:

D = Blank diameter
d = Shell diameter (See Sketch 1)

Thickness ratio is another factor affecting flow resistance i.e. ratio of blank diameter to metal thickness $\frac{D}{t}$ = $\frac{\text{Thickness of metal}}{\text{Blank diameter}}$

As this ratio decreases the tendency to wrinkle increases, making it necessary to apply more blank holding pressure to prevent wrinkle formation. This in turn demands lower reductions, better quality die material and more careful lubrication of the blanks. In other words the thinner the metal in relation to the blank dia. the more difficult will it be to make a limit draw or maximum reduction.

% Reduction in Dia. $\frac{D-d}{D} \times 100$	% Thickness ratio $\frac{t}{D} \times 100$ Double Action Press with B.H.	Single Action Press with B.H.	Single Action without B.H.
30%	.15%	.25%	2.0%
35%	.20%	.35%	2.5%
40%	.30%	.40%	3.8%
45%	.40%	.50%	3.3%
48%	.50%	.60%	[illegible]

Note: B.H. = Blank Holder or Pressure Ring.

Examples of Thickness Ratios & Corresponding Reductions

Shell	Blank	$\frac{T}{D} \times 100$
#1	12" dia. x .060	$\frac{.060}{12} \times 100 = .5\%$
#2	12" dia. x .018	$\frac{.018}{12} \times 100 = .15\%$

	Blank	Reduction		Shell Size	
		1st draw	2nd draw	1st draw	2nd draw
#1	12"	48%	---	6¼"	---
#2	12"	30%	27%	8-3/8"	6¼"

Redraws

1st draw from Blank	2nd Draw	3rd Draw	4th Draw	Total Reduction from Blank
35%	20%	15%	10%	52%
40%	23%	18	13	63½%
45	27	22	16	73½%
48	30	25	18	77½%

Recommended maximum reductions (total) without annealing

Deep Draw Steel	-	67 %
Stainless Steel	-	50% - 52%
Soft Aluminum	-	25% - 35%

In a drawing operation the increase in hardness is proportioned to the cold work done and as the hardness increases the ductibility and plasticity decreases.

The depth of a rectangular draw should not exceed 4 to 6 times the corner radius. A shell having a corner radius of less than 1/8 of its depth should not be attempted in one draw. If possible, in drawing a rectangular shell in more than one draw, make the initial punch round - (cheaper).

One draw will change average material from dead soft to 1/2 hard or slightly more depending on amount of cold work done.

C = CONSTANT .6 TO .7
ALLOW FOR FRICTION ETC.

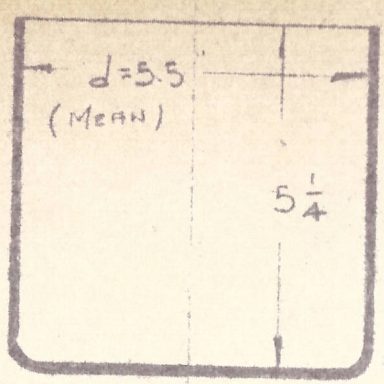
FORMULA 1

$$P = \pi d t s_y \left(\frac{D}{d} - .7\right)$$

S_Y = YIELD STRENGTH # P.S.I. (ANNEALED)

P = TOTAL APPLIED DRAWING PRESSURE

T = METAL THICKNESS

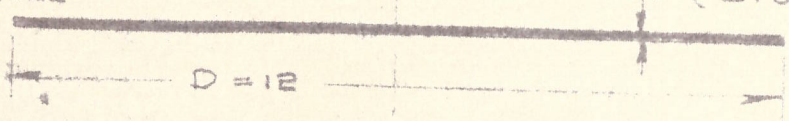


FORMULA 2

$$P_{MAX} = \pi d t s_y$$

P_{MAX} = TOTAL BREAKING PRESSURE (MIN)

ST = ULTIMATE ST
ANNEALED PSI.



DRAWING PRESSURE

$$P = 3.14 \times 5.5 \times .08 \times 50000 \left(\frac{12}{5.5} - .7\right)$$

$$= 102000 \text{ LBS}$$

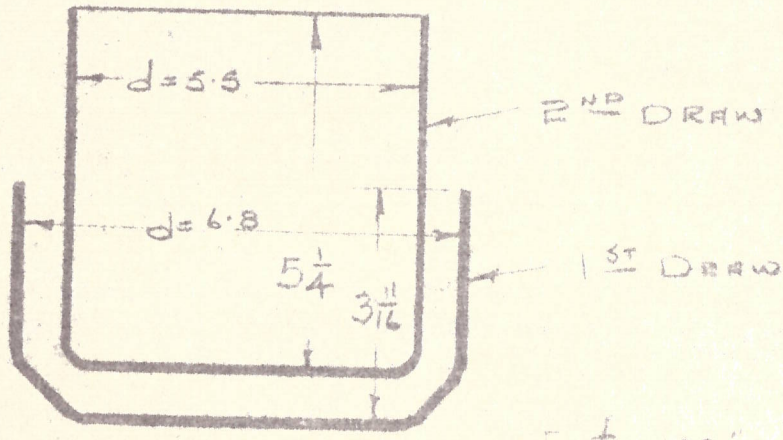
STRENGH OF SHELL

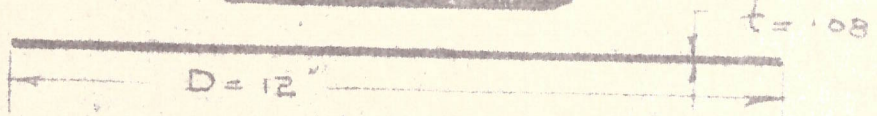
$$P_{MAX} = 3.14 \times 5.5 \times .08 \times 55000$$

$$= 76000 \text{ LBS}$$

INCORRECT

DRAWING PRESSURE EXCEEDS THE METAL STRENGH





DRAWING PRESSURE

$$P = 3.14 \times 6.8 \times .08 \times 50000 \left(\frac{12}{6.8} - .7\right)$$

$$= 90500 \text{ LBS}$$

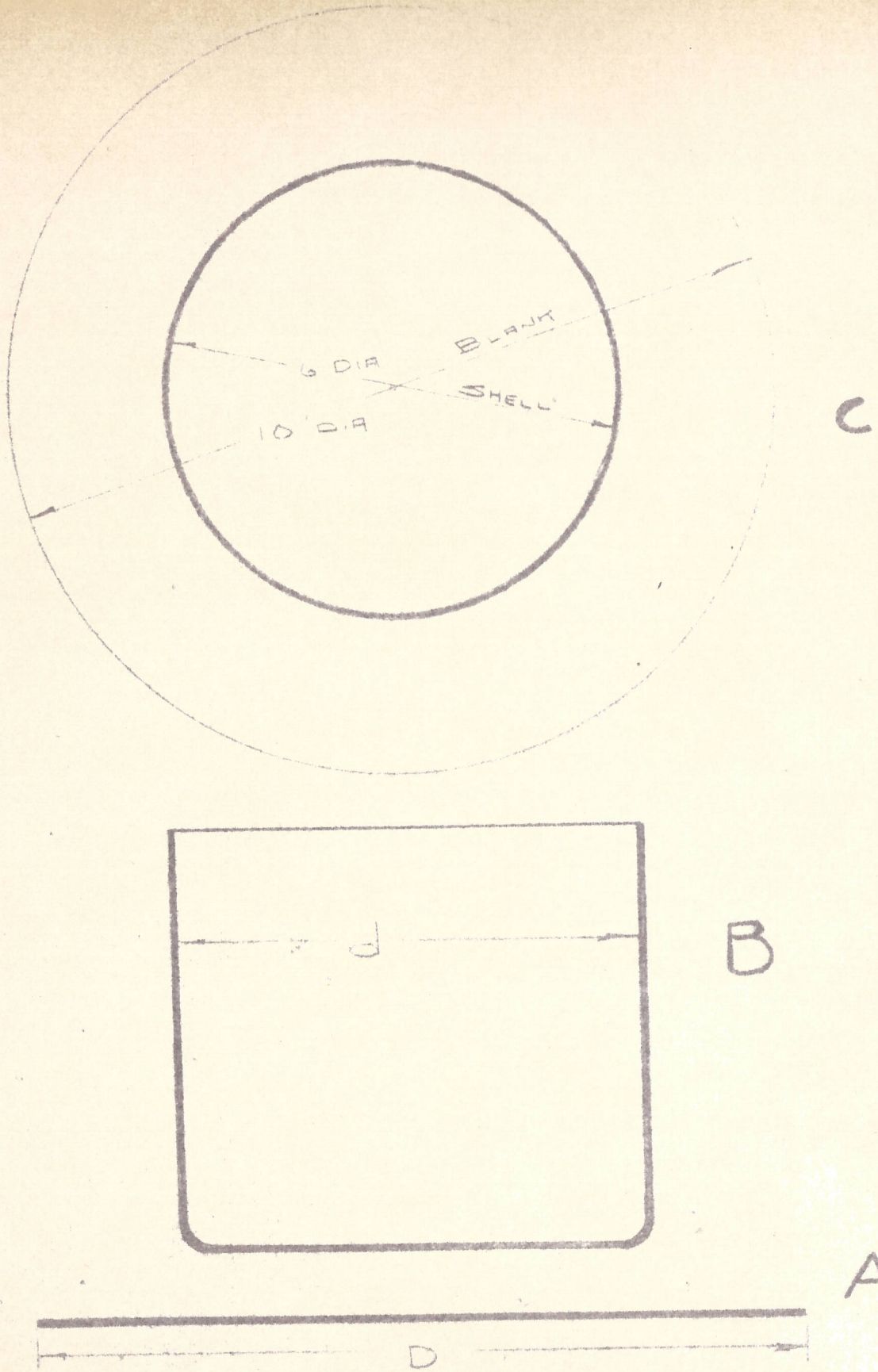
STRENGTH OF SHELL (1ST DRAW)

$$P_{MAX} = 3.14 \times 6.8 \times .08 \times 55000$$

$$= 94000 \text{ LBS}$$

FIG 18

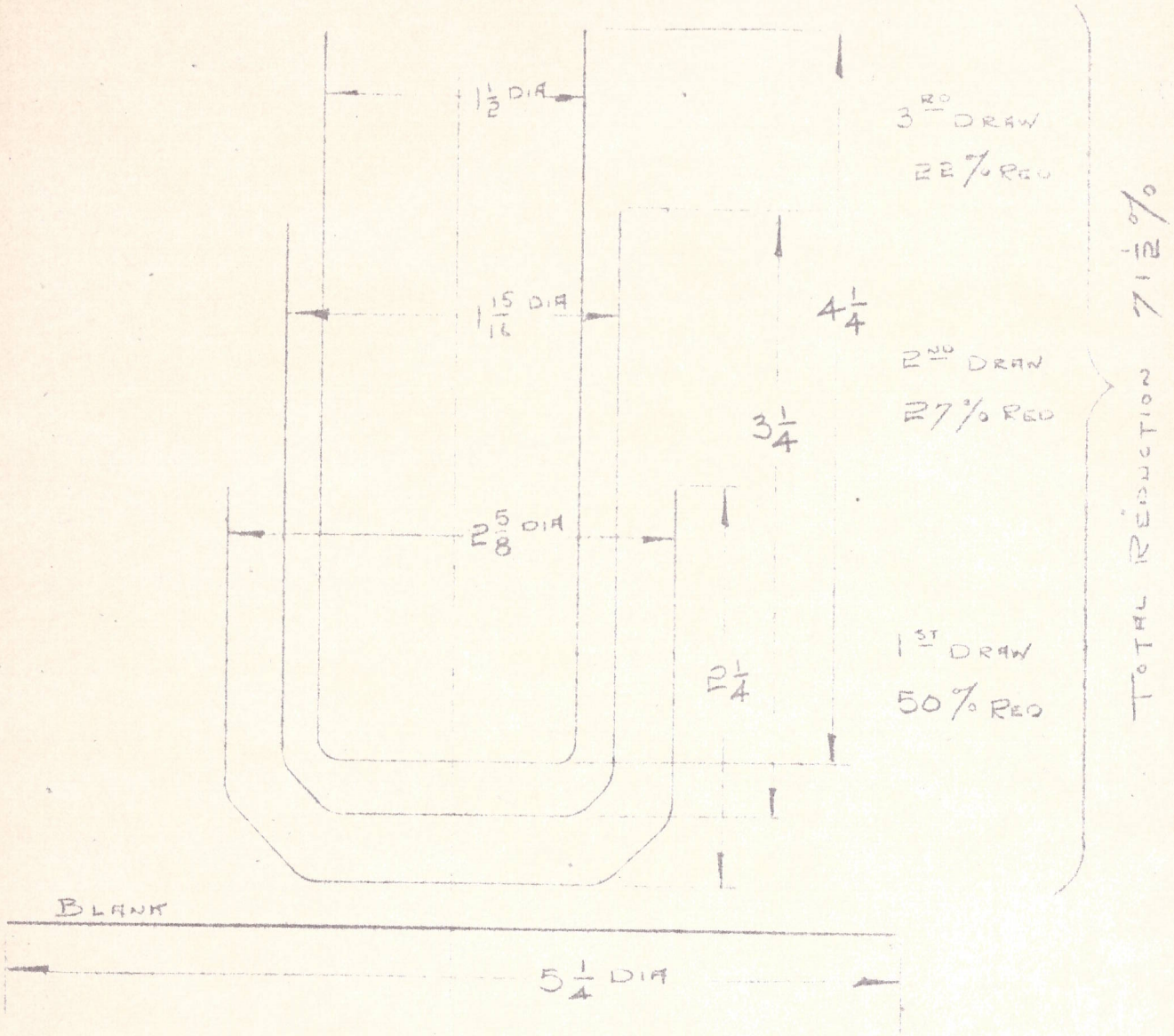
CORRECT



$$\text{REDUCTION} = \frac{D-d}{D} \times 100 = \frac{10-6}{10} \times 100 = 40\%$$

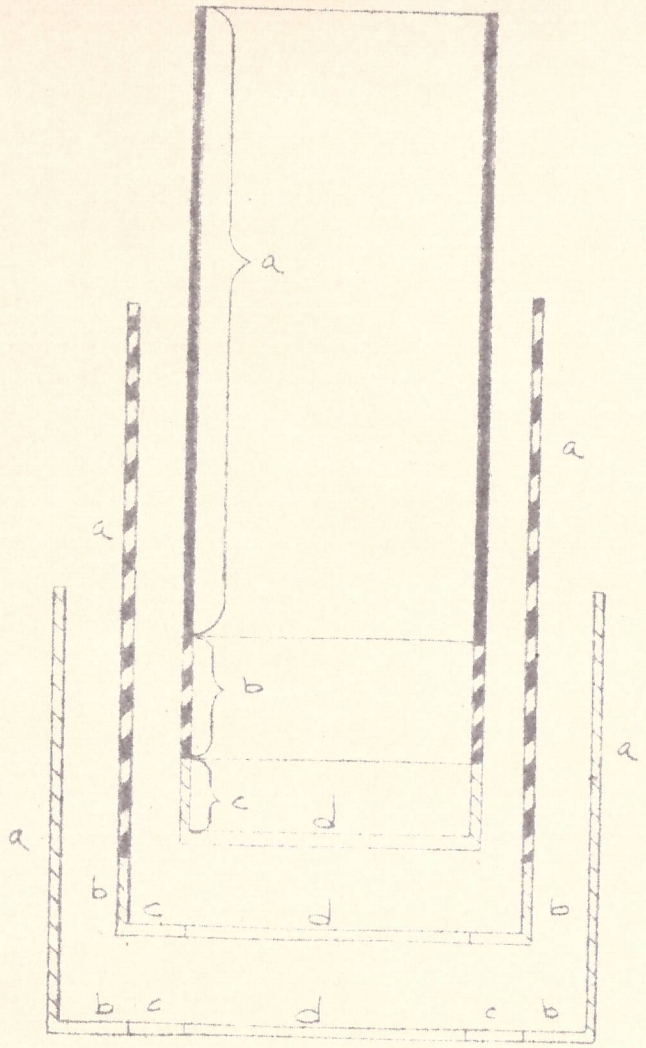
REDUCTION DIAGRAM

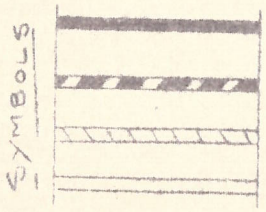
FIG 19



71 1/2 % REDUCTION ON 350 ALUMINUM WITHOUT INTERMEDIATE ANNEALING

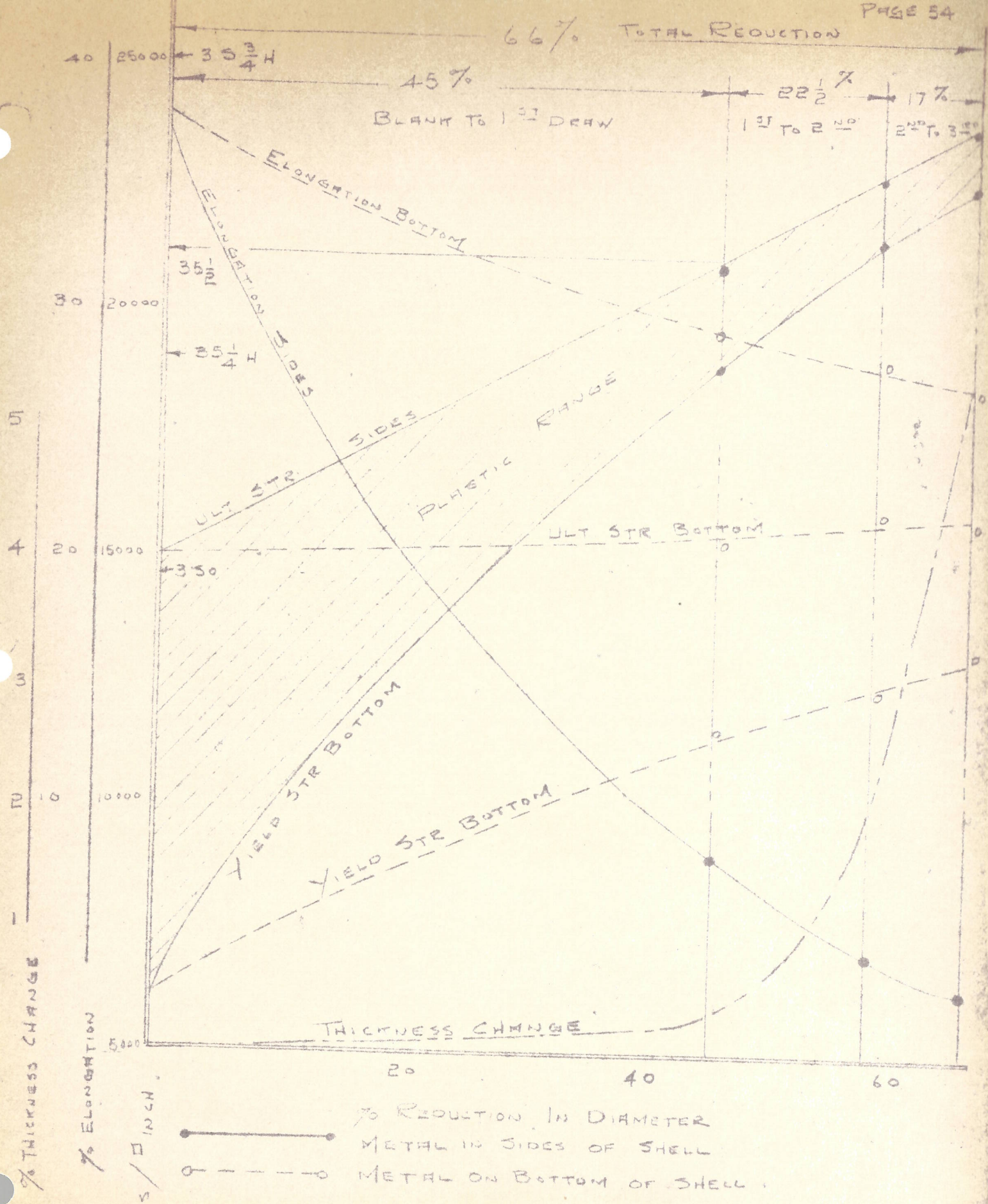
FIG 20





HARDNESS ZONES

FIG 21



THE EFFECT OF DRAWING ON THE MECHANICAL PROPERTIES OF 3.50 ALUMINUM

FIG 22

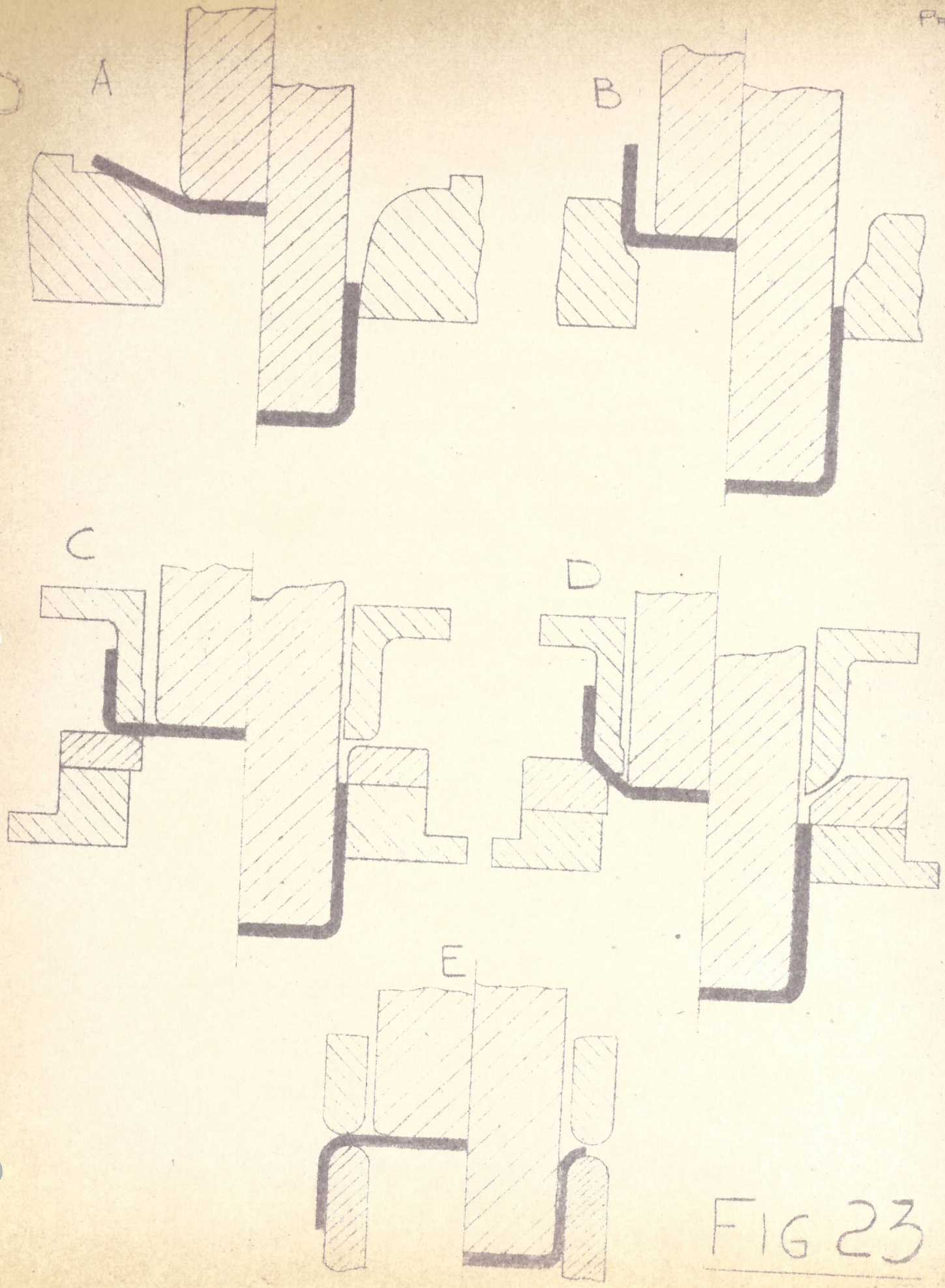
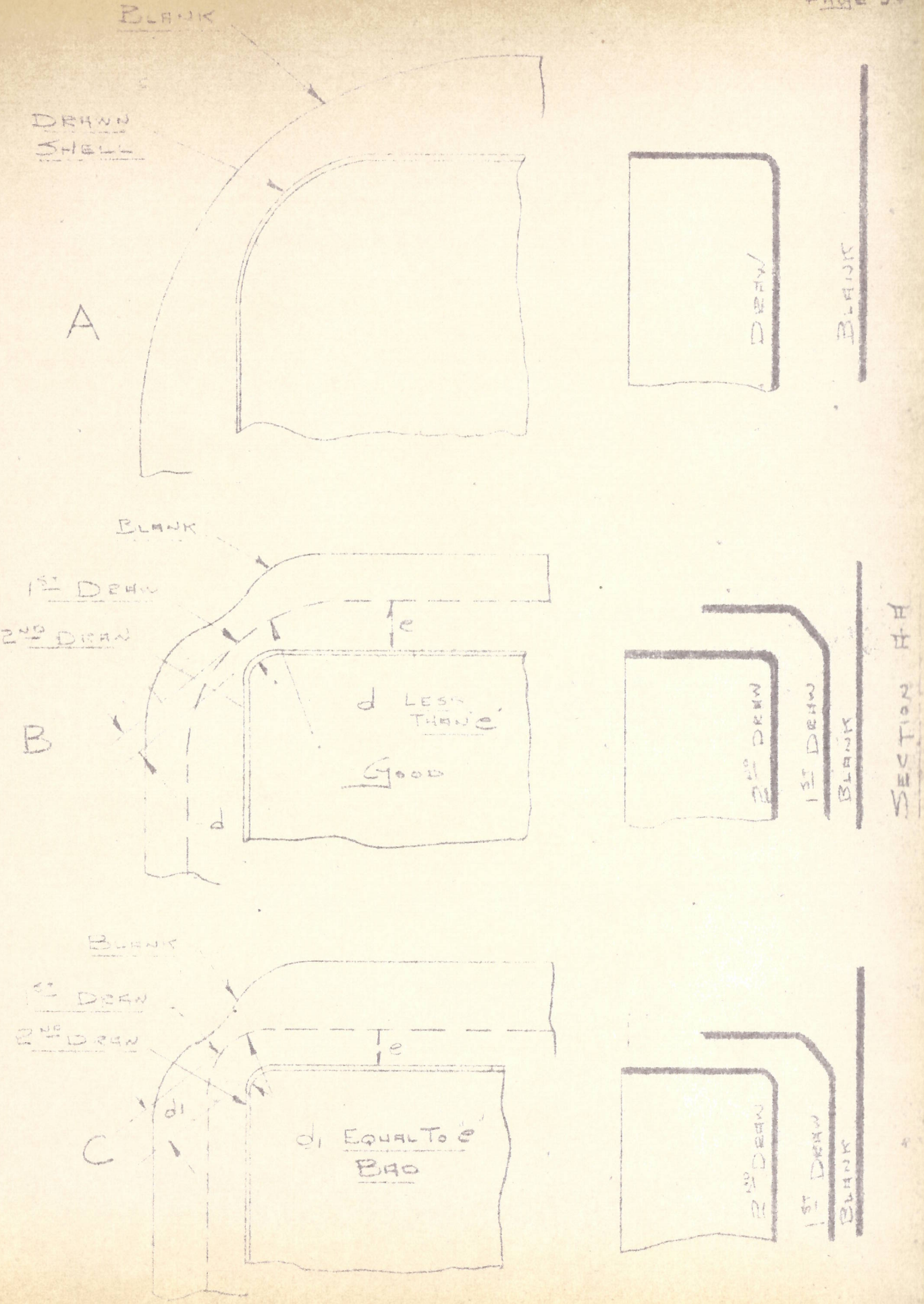
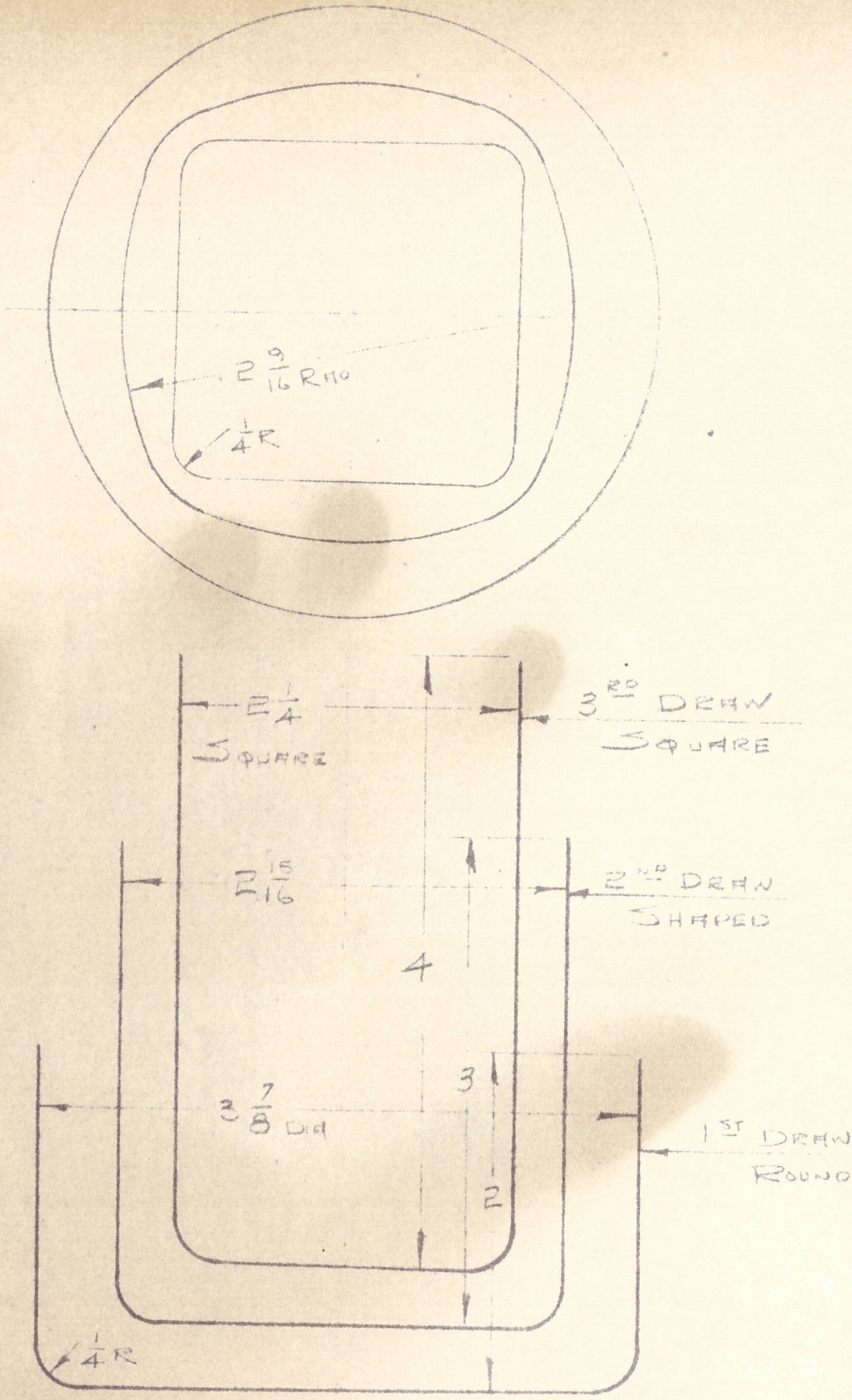


FIG 23



REDRAWS ON RECTANGULAR SHELLS

FIG 24



REDUCTIONS ON A SQUARE SHELL FROM A ROUND BLANK

FIG 25

Free drawing is that type of drawing operation in which there is no appreciable change in total area because of thickness reduction or increase.

The amount of drawing which may be successfully done in one operation depends on the kind of metal and its temper as well as the correctness and consistency of such factors as chemical composition, crystal or grain size, ductibility, rate of work hardening, directionality, reaction to annealing when more than one operation is necessary, die design, and the design peculiarities of the component being drawn.

In free drawing, the metal is subjected to both compressive and tensile stresses and the resistance to flow increases as the draw proceeds.

The amount of cold work possible in one step or operation depends on the plasticity of the metal being drawn. The plasticity drops in proportion to the cold work done and when a point is reached where the metal is no longer plastic, annealing is then necessary in order to restore its plasticity, before further cold work can be done.

Plasticity is defined as the quality by virtue of which a substance may undergo a permanent change in shape without rupture.

A bend in a piece of metal involves no metal movement except that which occurs at the bend radius. The fibres in the bend area which are located inside this axis are compressed but the metal which is not in the actual bend area remains unchanged.

A draw involves flow in all the area units that are moved towards or over the die radius and a marked unit area will show a change in shape proportionate to the amount of metal movement from its initial position to its final position.

In a drawing operation the metal flow in any selected unit of area has the following characteristics:

(1) The flow is proportionate to the applied stress.

(2) It involves a 3 dimensional change in the unit, change in length, width and thickness.

(3) It takes place under both tensile and compressive stresses.

(4) It is uniform when the stresses are balanced.

Figure 2

The thickness change from t to t + is due to the progressive crowding of the area units into smaller confining boundaries which sets up compressive stresses in the area that is being moved in the die radius and which if uncontrolled will permit the starting of wrinkles.

Figure 2 - cont'd....

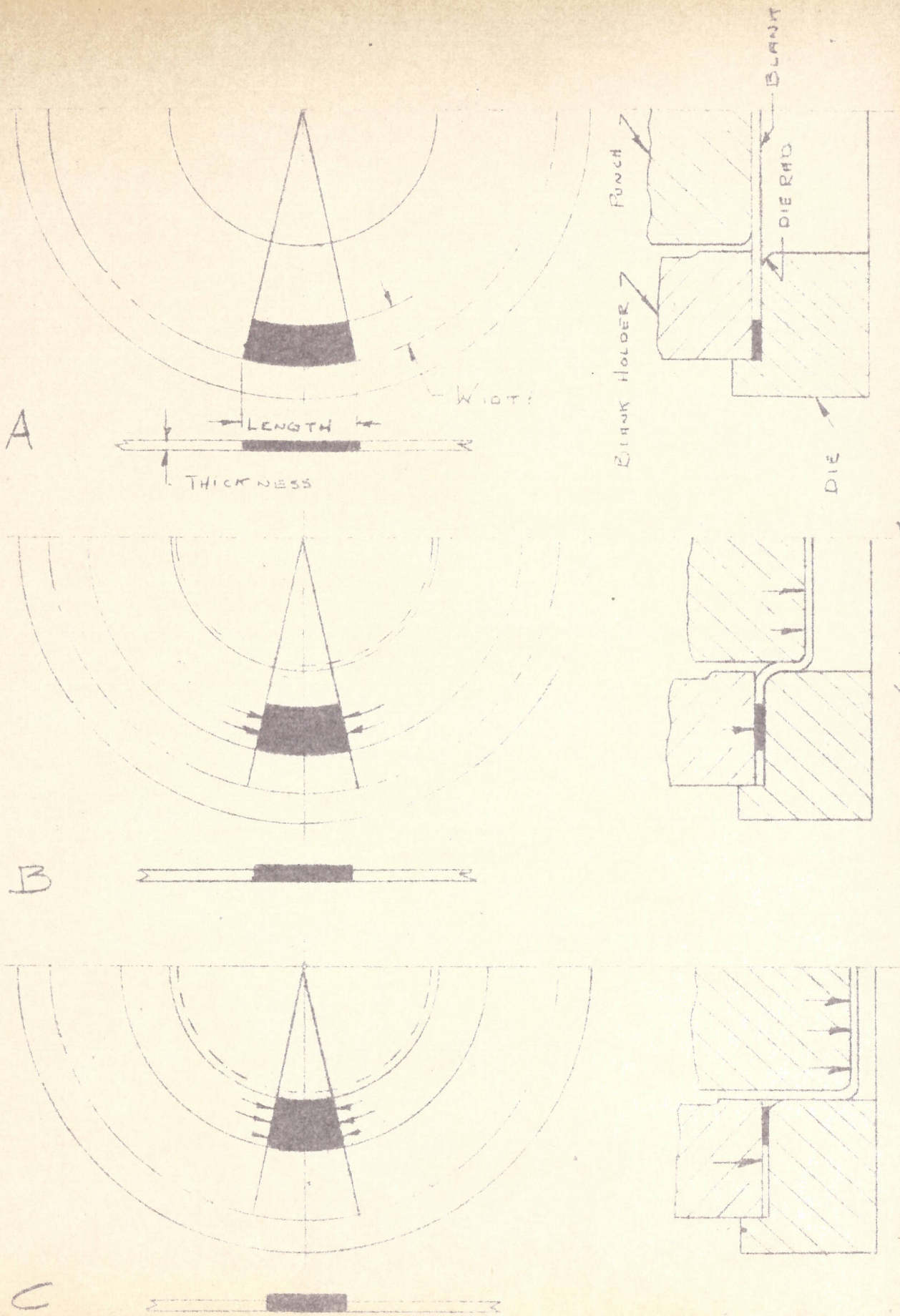
Compressive stresses are induced in that area which has not been drawn over the die radius, the metal is subjected to a tensile stress. Compressive stresses in the flange ase rapidly as flow proceeds and this together with the resistance to flow over the die radius retards the movement of the metal. The punch pressing on the bottom of the shell must overcome this resistance thus putting a tensile stress on the side-wall metal which has moved over the die radius.

----------oOo----------

BLANK HOLDERS

A blank which is thin in relation to its diameter will have a greater tendency to wrinkle in the area under compressive stress than one which is relatively thick.

The shape of the shell being drawn governs to some extent the blankholding pressure which must be applied to prevent wrinkle formation. In general, considering that part of the blank which covers the die opening, the greater the distance from die radius to the point of punch contact in relation to the die diameter the greater will be the area out of control and in consequence the higher must the blank holding pressure be to prevent wrinkling or puckering.



CAUSE OF FLANGE WRINKLES

FIG 26

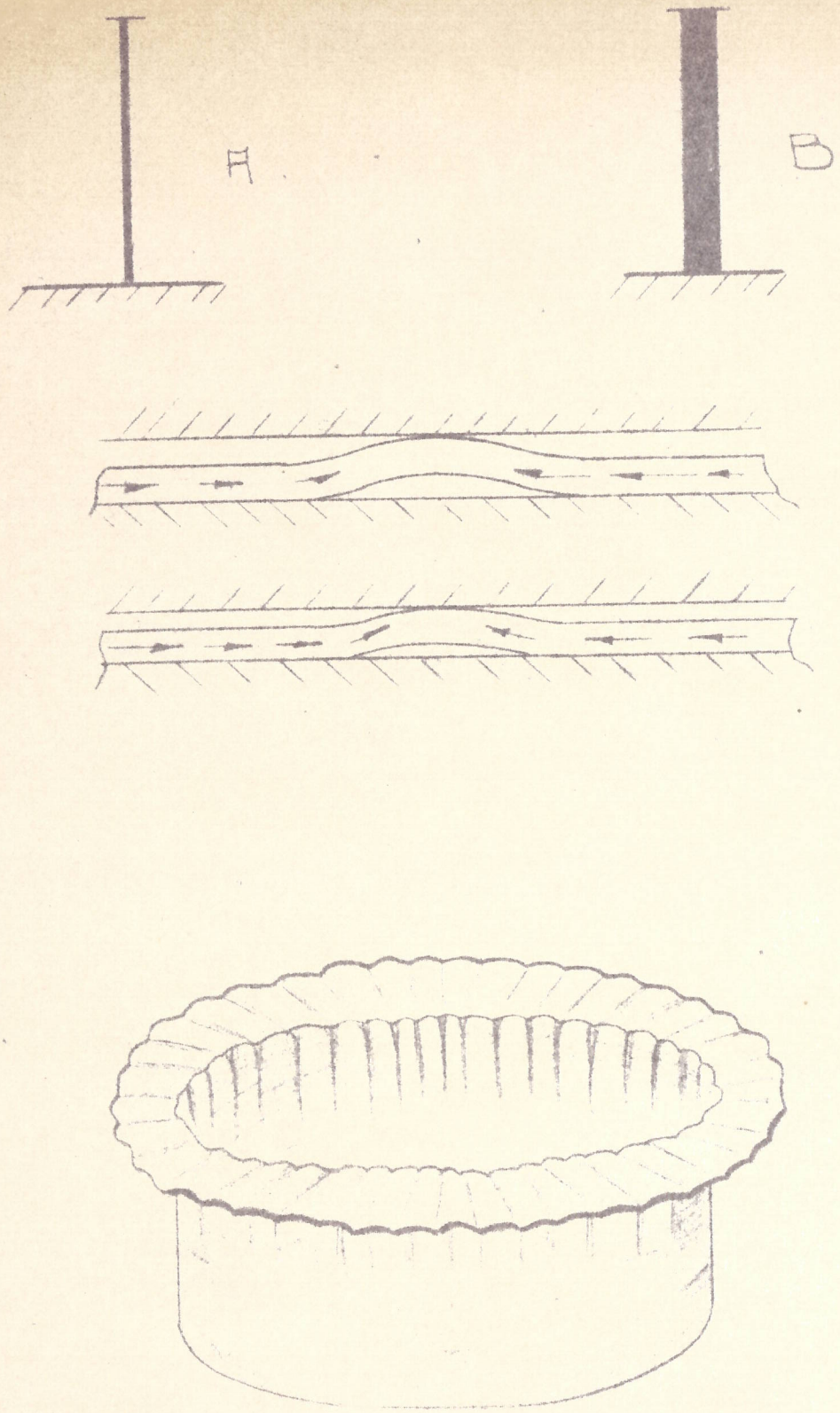
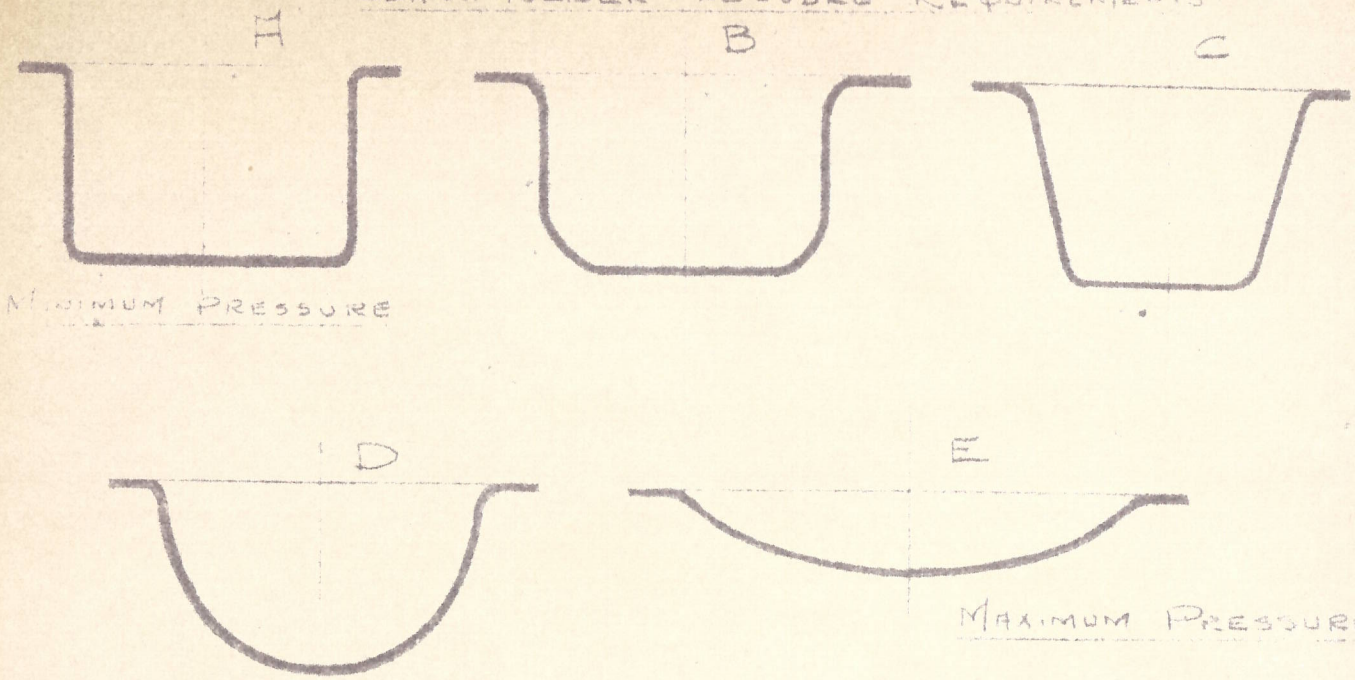
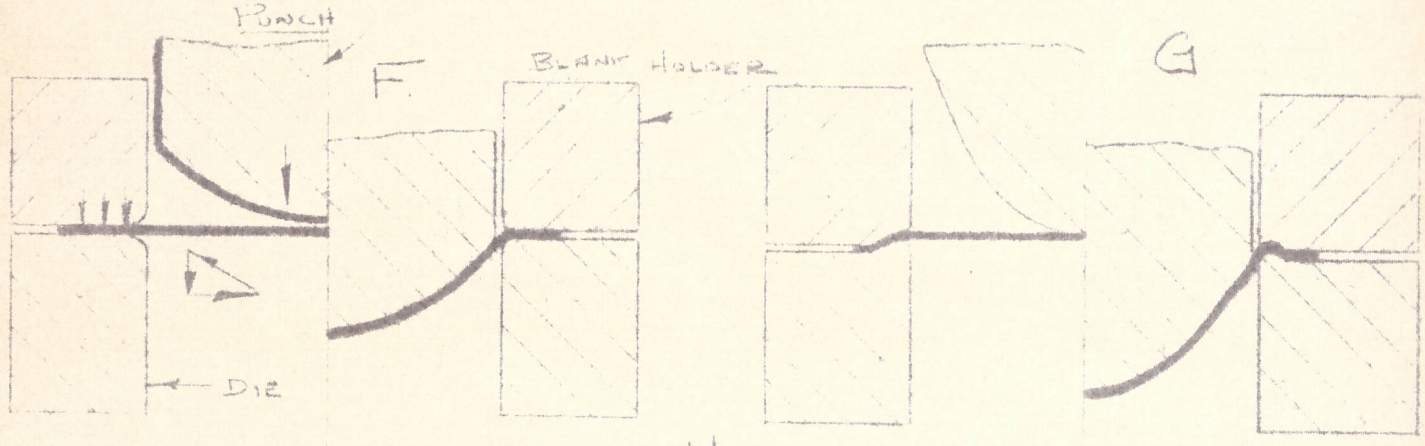


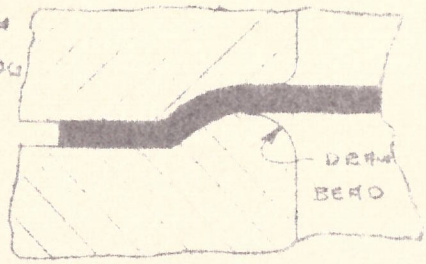
FIG 27

TYPICAL HOLLOWARE SHAPES ARRANGED IN THE ORDER OF BLANKHOLDER PRESSURE REQUIREMENTS





DIE FOR SHAPE E SHOWING THE RATIO OF BLANKHOLDING PRESSURE TO DRAWING PRESSURE.

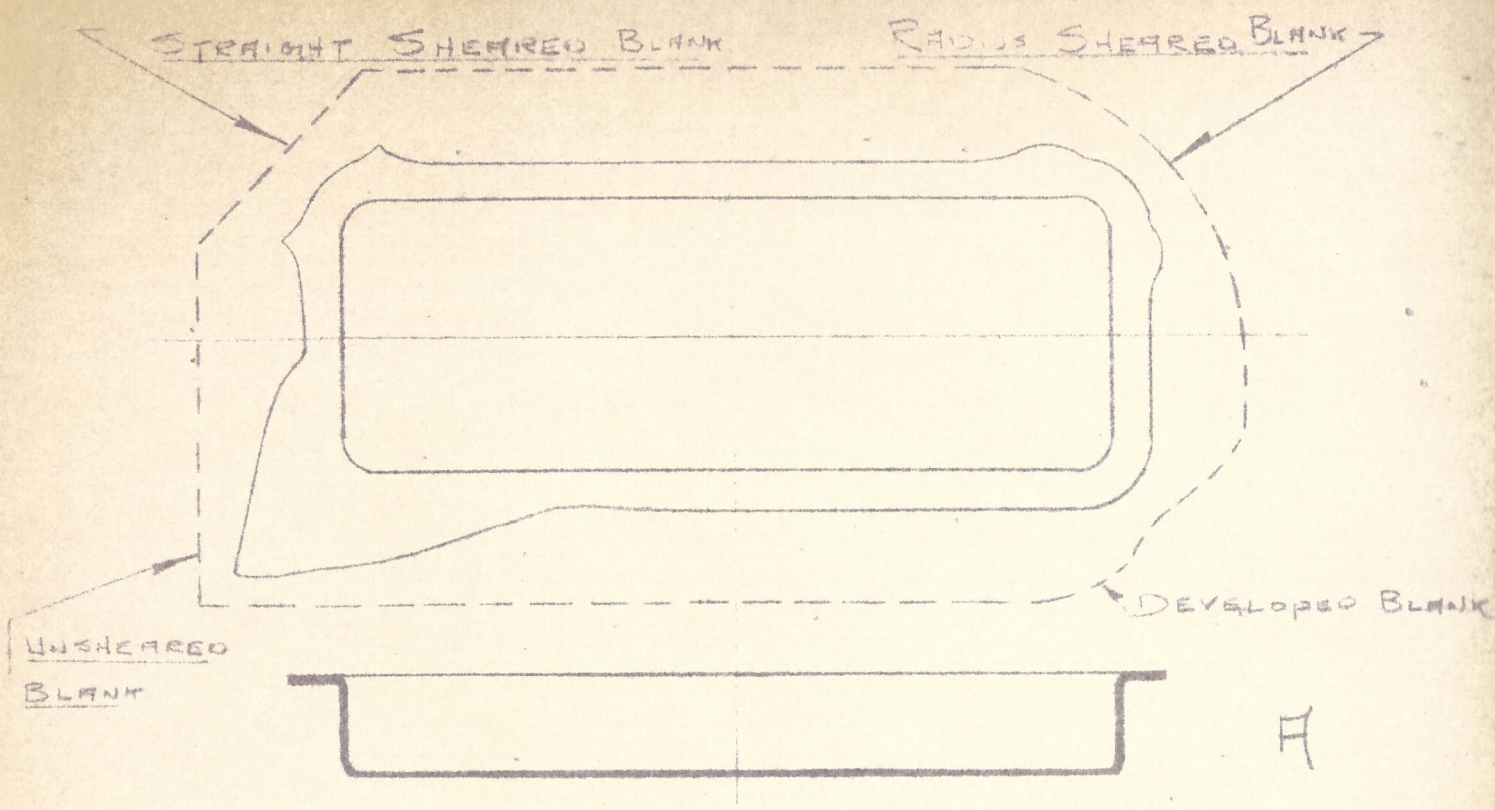


DETAIL OF DRAW BEAD

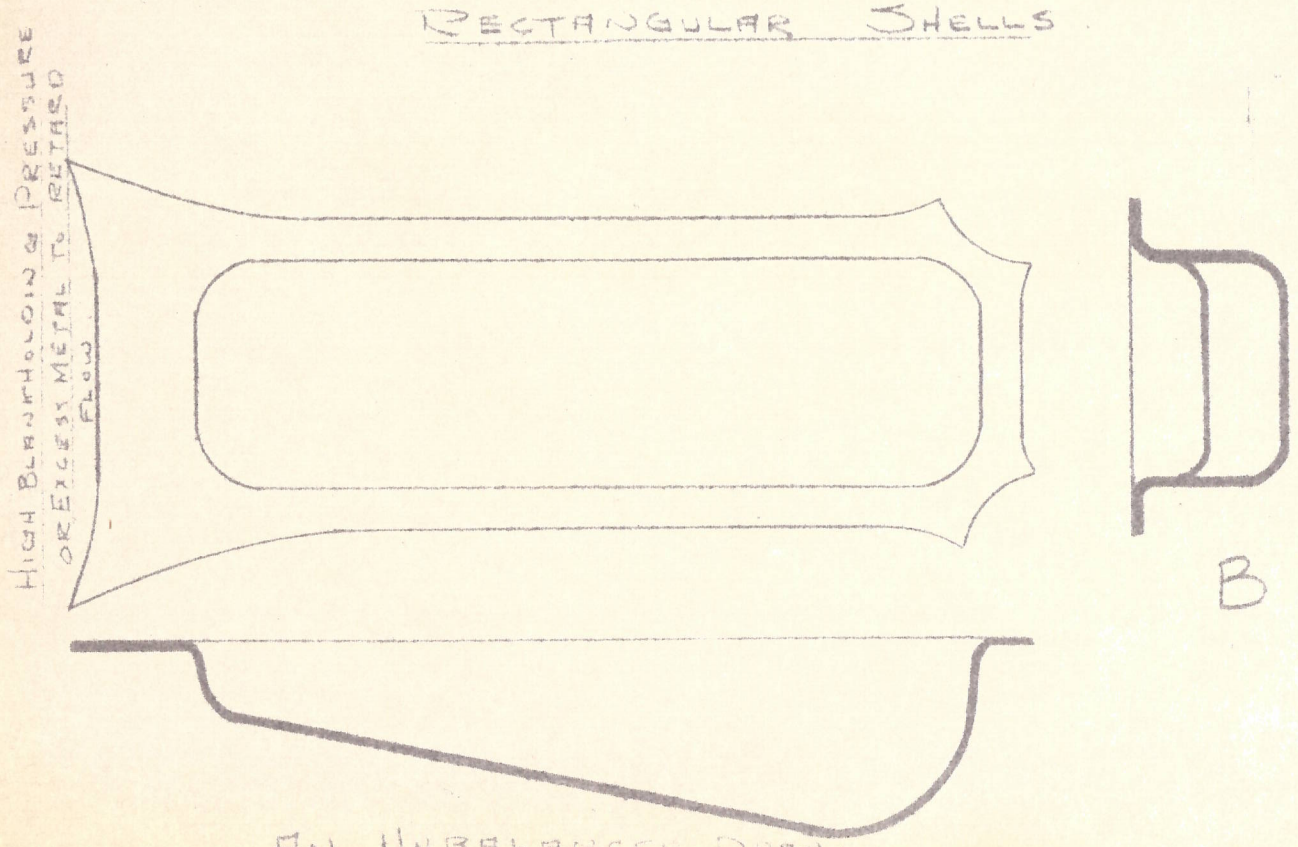
TYPICAL DRAW BEAD DIE FOR SHAPES D & E

BLANKHOLDING PRESSURE

FIG 28

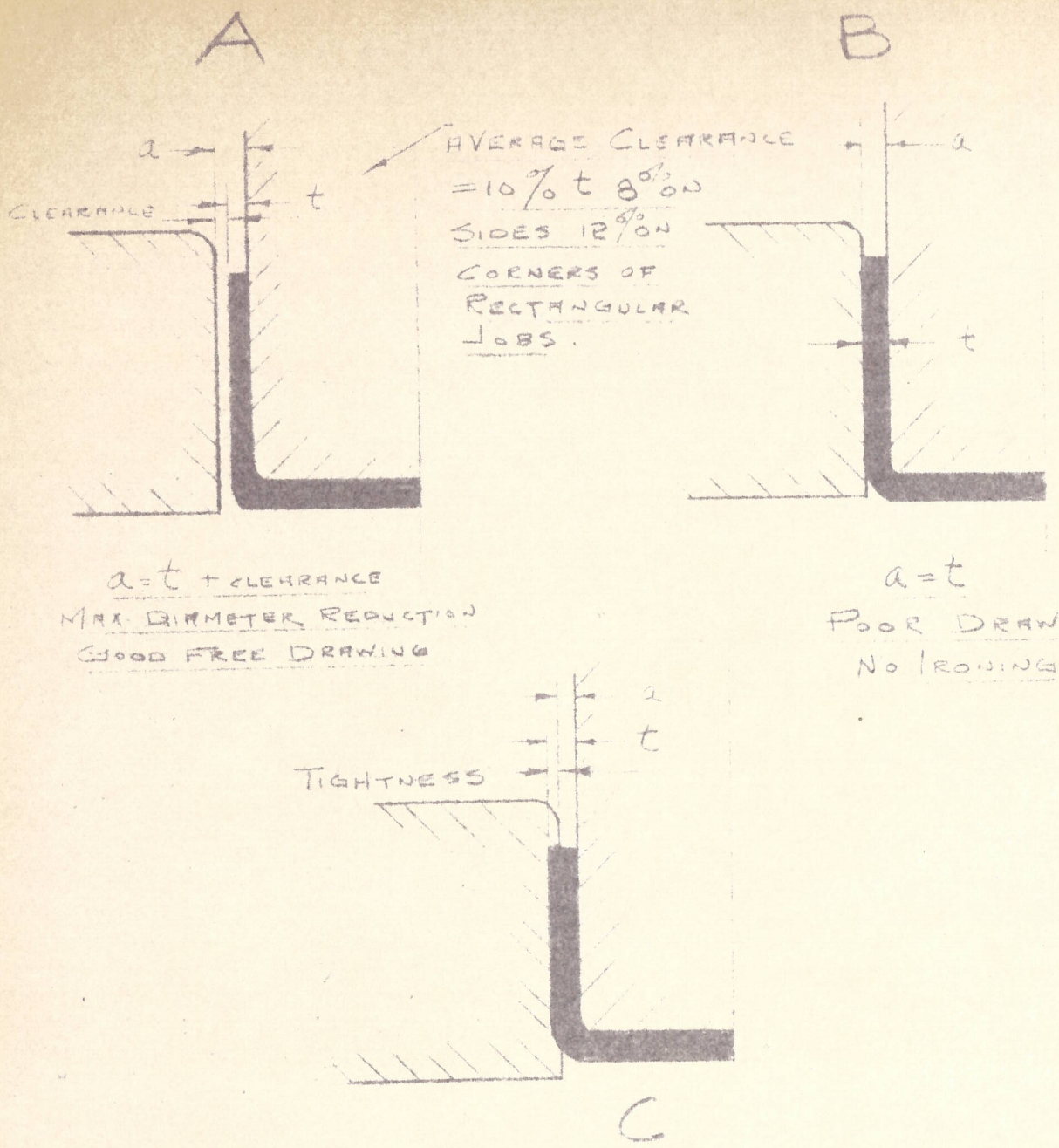


THE EFFECT OF BLANK SHAPE ON THE CORNERS OF RECTANGULAR SHELLS



AN UNBALANCED DRAW

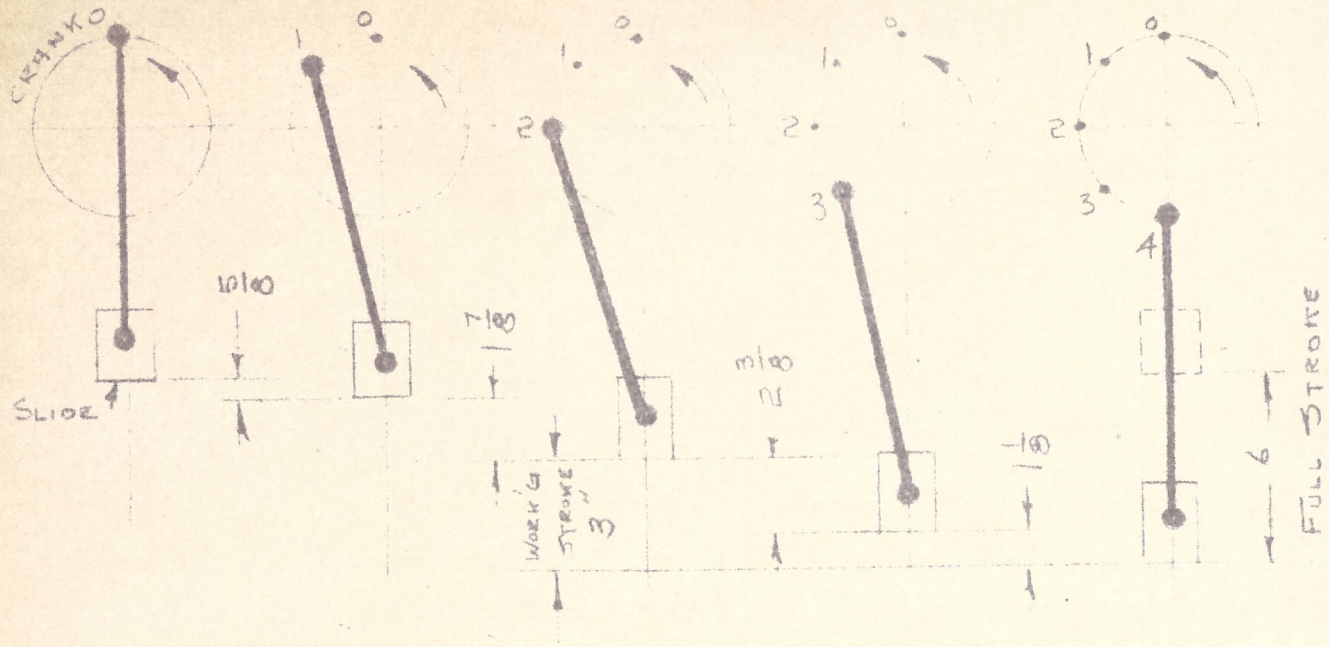
FIG 29



t = METAL THICKNESS

a = DIE SPACE.

FIG 30



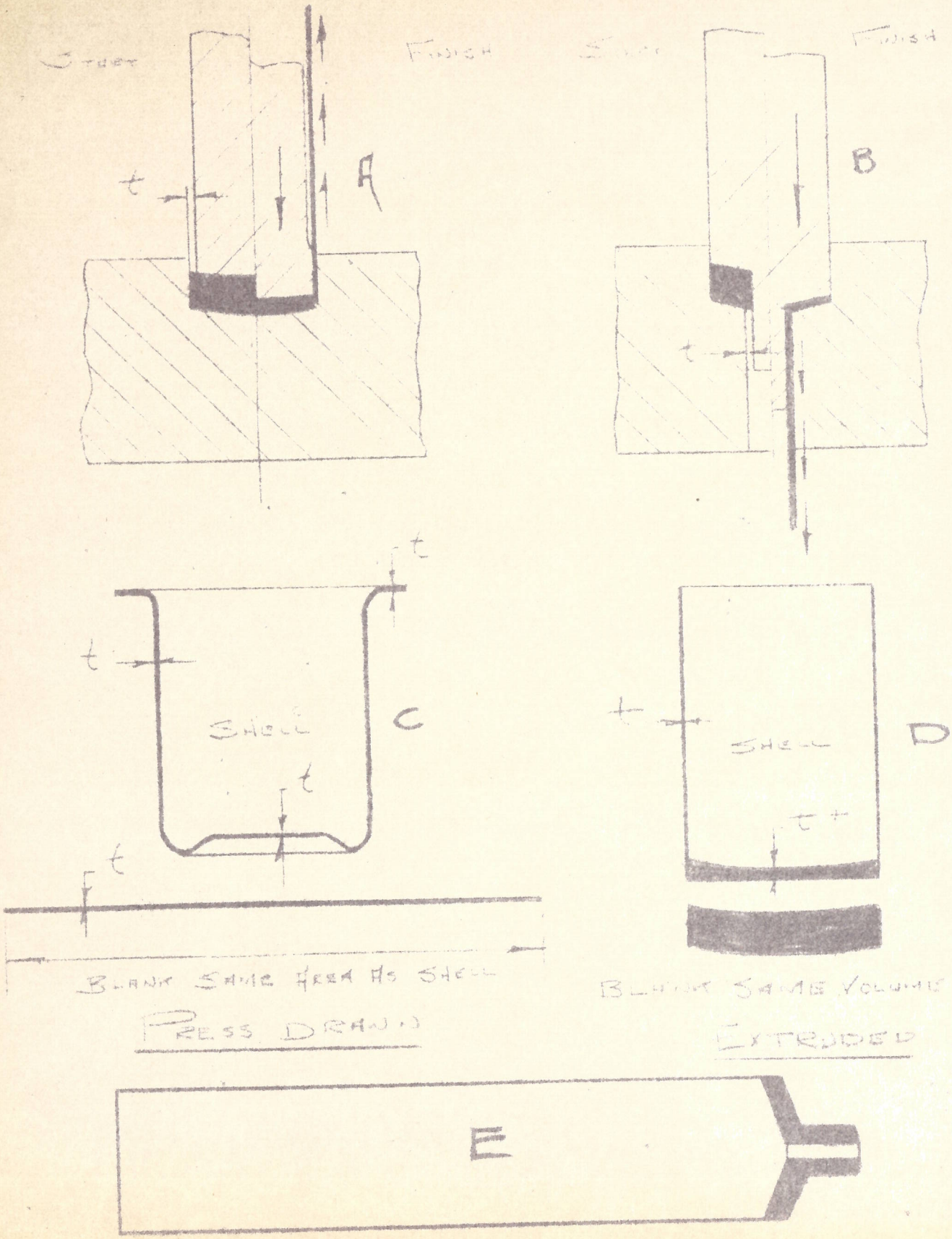
6 STROKE CRANK SPEED 15 RPM = 1 REV IN 4 SEC

MOVEMENT OF CRANK	SLIDE TRAVEL	TIME	SLIDE SPEED FPM
FROM 0 TO 1	$\frac{5}{8}$	$\frac{1}{2}$ SEC	6
FROM 1 TO 2	$1\frac{7}{8}$	$\frac{1}{2}$ SEC	19
FROM 2 TO 3	$2\frac{3}{8}$	$\frac{1}{2}$ SEC	24
FROM 3 TO 4	$1\frac{1}{8}$	$\frac{1}{2}$ SEC	11
FROM 4 TO 0 RETURN	6	2 SEC	15

VELOCITY IN DIFFERENT SPEED

OF CRANK OPERATED PRESSES

FIG 31



Impact Extruded Tooth Paste Tube

FIG 3B

Drawing Speed (in F.P.M.) Ironing

	S.A. Presses	D.A. Presses	
St'l's. Stl.	40 F.P.M.	30	20
Lo Cabb Stl.	50	40-50	25
Zinc	150 (?)	40-50	--
Alum.	160	50-80	70
Copper	150	65-85	60
Brass	200	80-100	70

With metals that are difficult to draw, the slower the press speed, the greater the uniformity with which the deformation will spread over a large area and therefore the deeper the draw that can be made per operation.

----------oOo----------

Draw Tools: fall into two main types:

(1) Those designed for use in double action presses.
(2) Those designed for use in single action presses.

The above two types may be sub divided as follows:

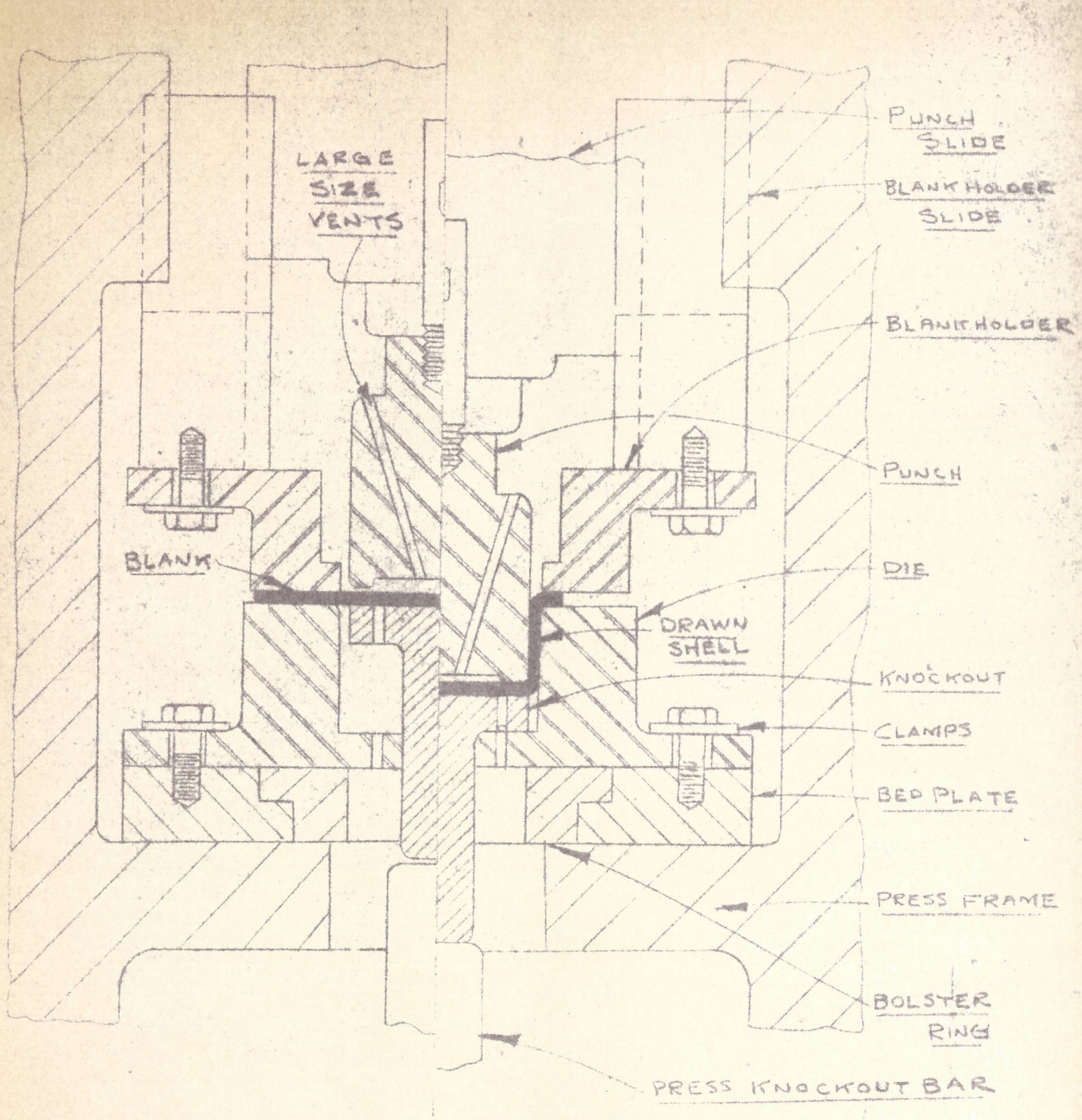
Double Action Draw Tools:

(a) Plain Draw Tools.
(b) Blank and Draw Tools.
(c) Redraw Tools.

Single Action Draw Tools:

(a) Plain Draw Tools.
(b) Single Blank and Draw Tools.
(c) Multiple Blank and Draw Tools.
(d) Progressive Blank & Draw or Blank & Form Tools.
(e) Redraw Tools.

Radius on bottom of punch should not be less than three times material thickness (in drawing).



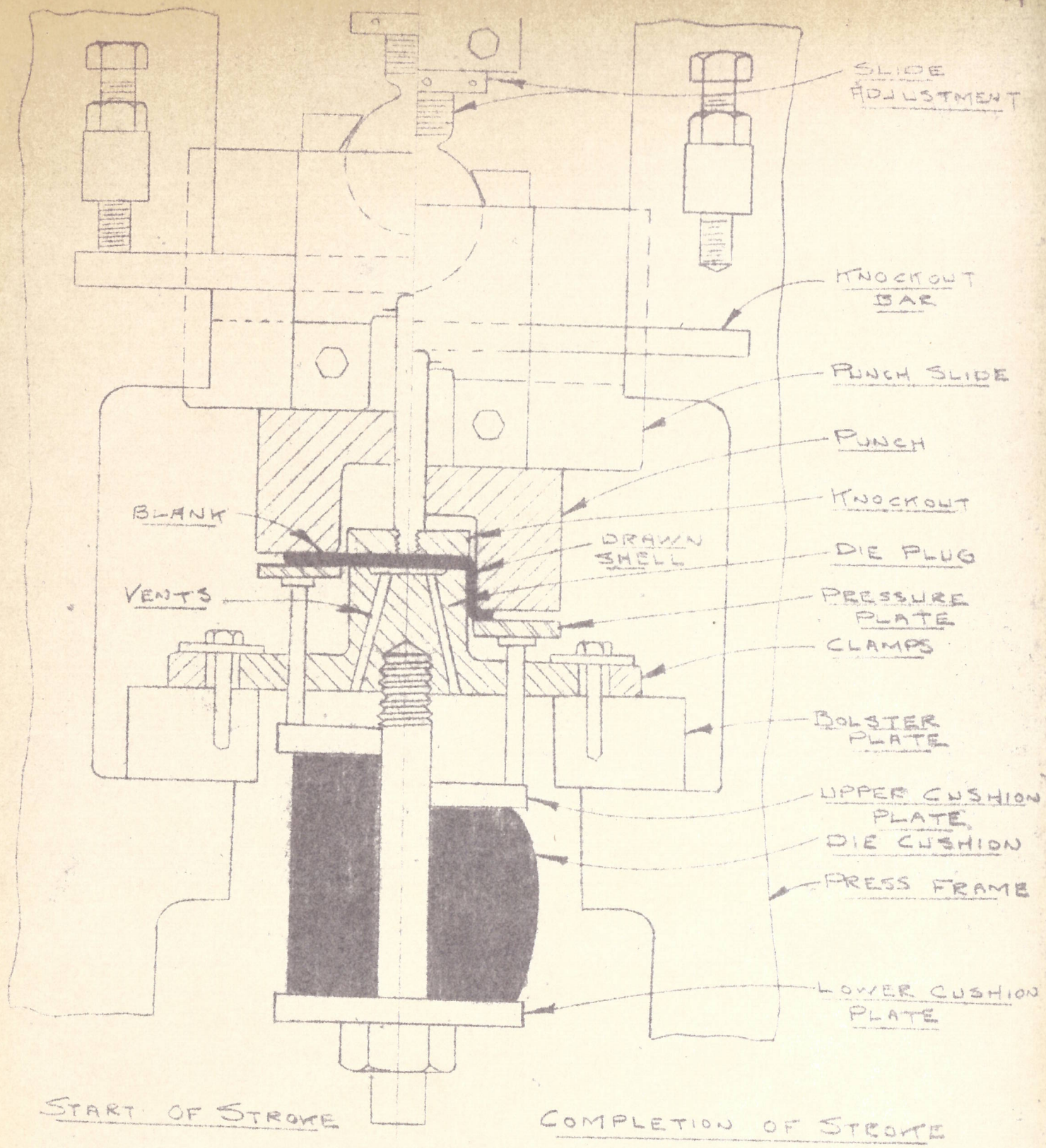
START OF STROKE

COMPLETION OF STROKE

DRAW TOOL

DOUBLE ACTION TYPE

FIG #1



DRAW TOOL
SINGLE ACTION TYPE
FIG. #5

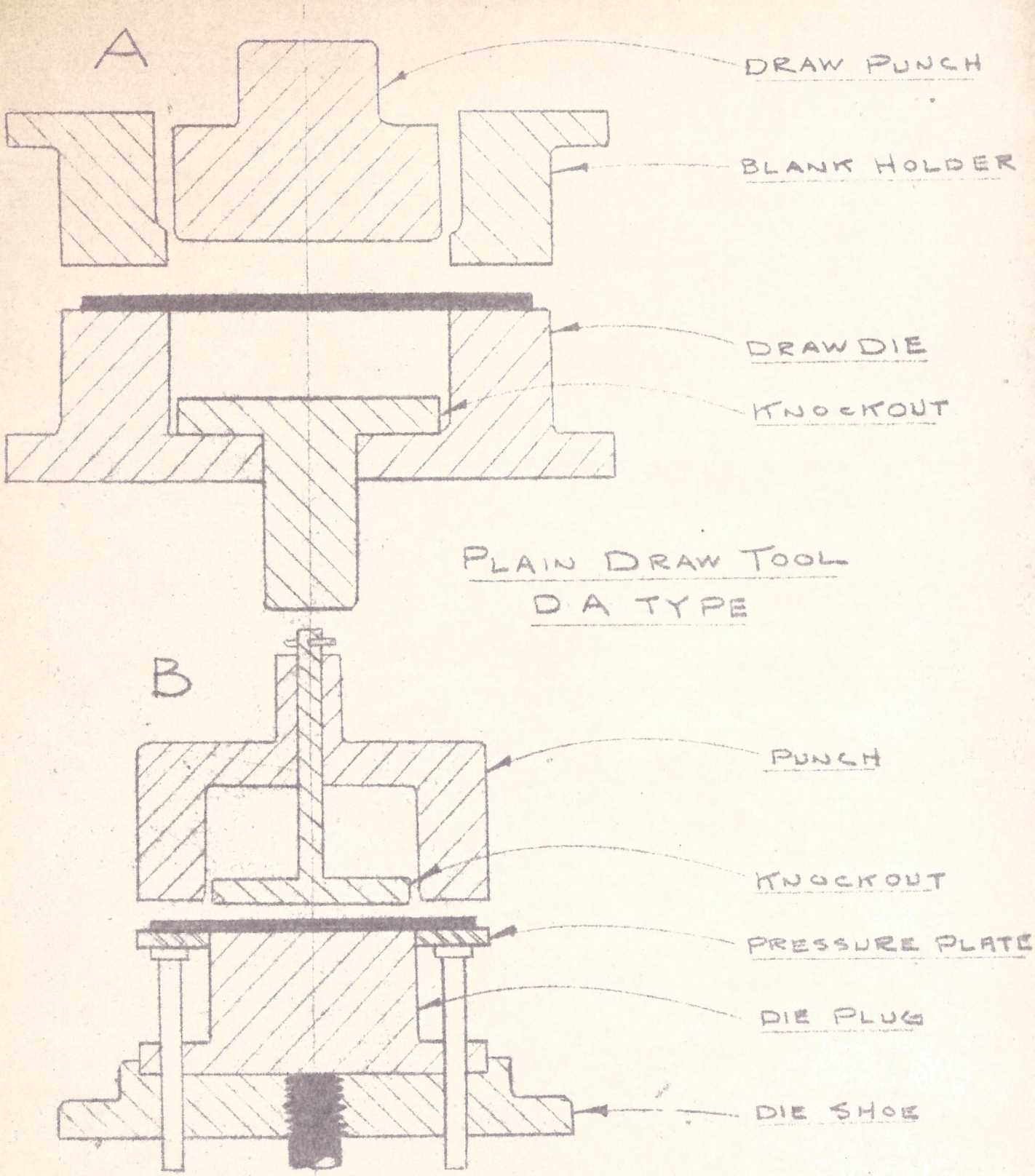
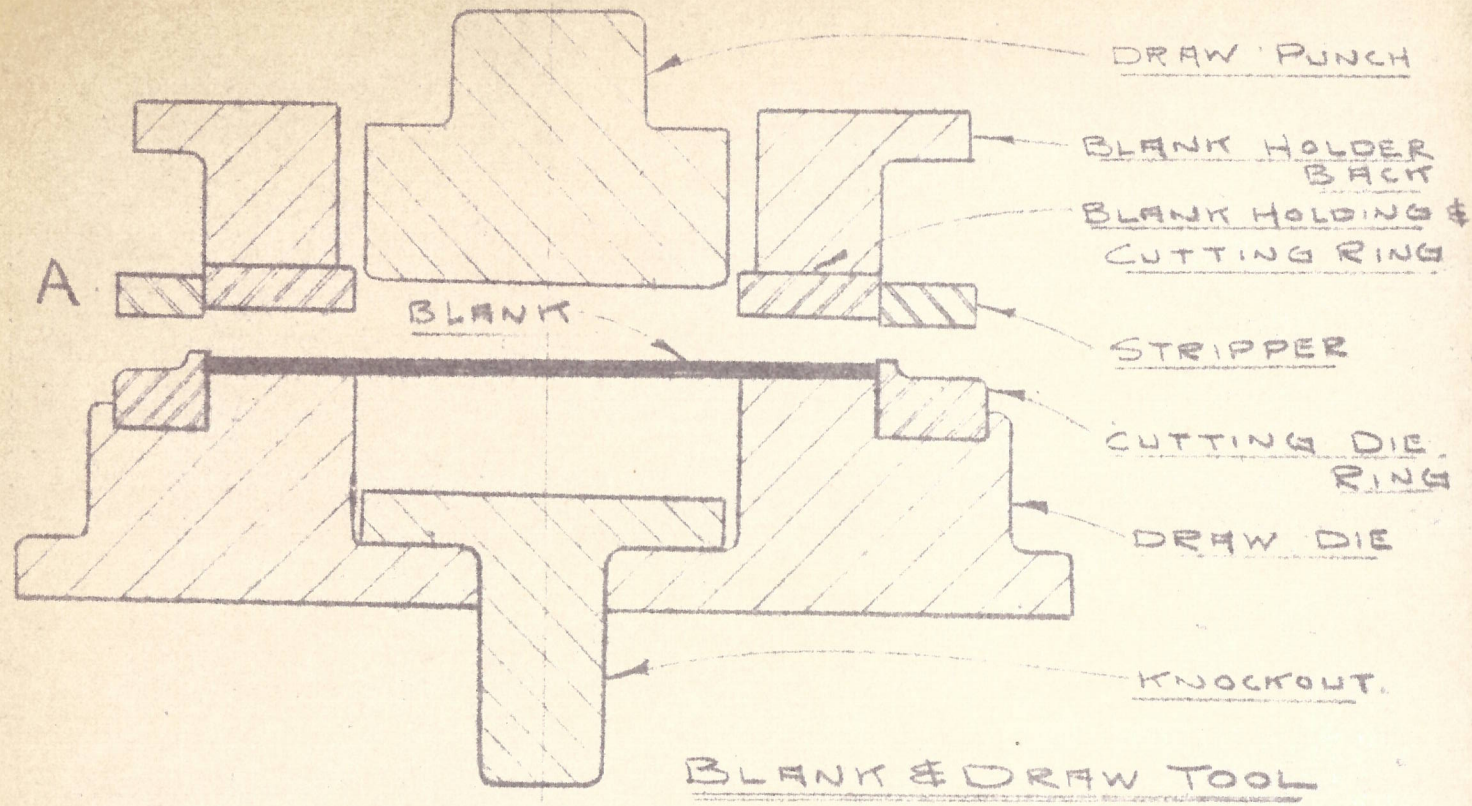
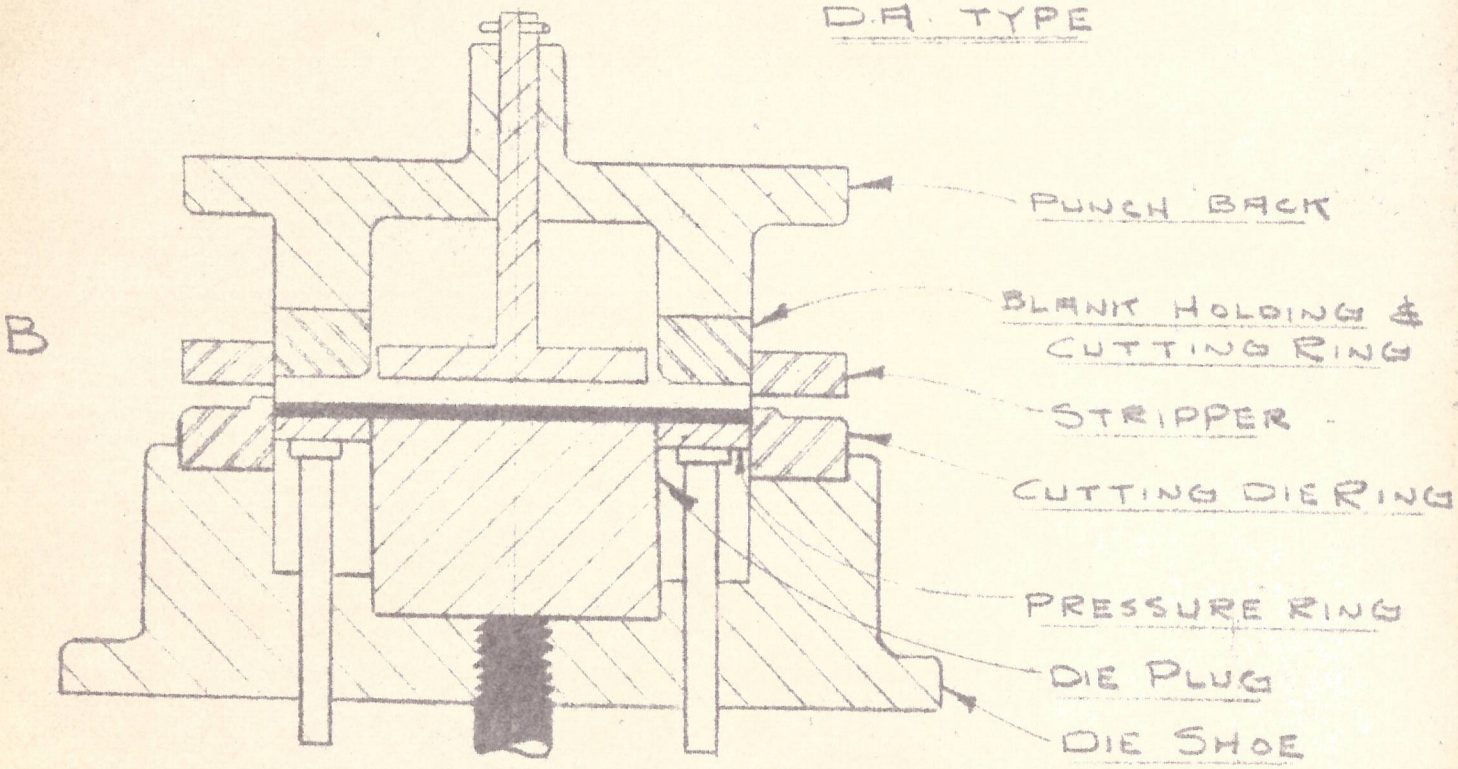

A
DRAW PUNCH
BLANK HOLDER
DRAW DIE
KNOCKOUT
PLAIN DRAW TOOL
D A TYPE
B
PUNCH
KNOCKOUT
PRESSURE PLATE
DIE PLUG
DIE SHOE
PLAIN DRAW TOOL
S A TYPE

FIG 7



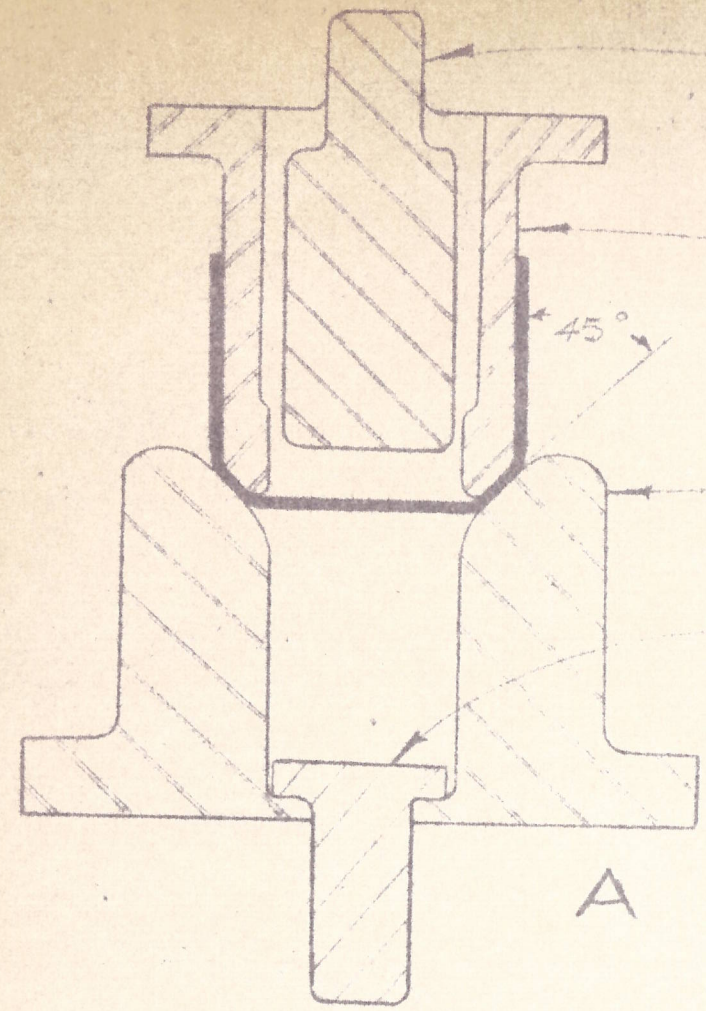
BLANK & DRAW TOOL
D.A. TYPE



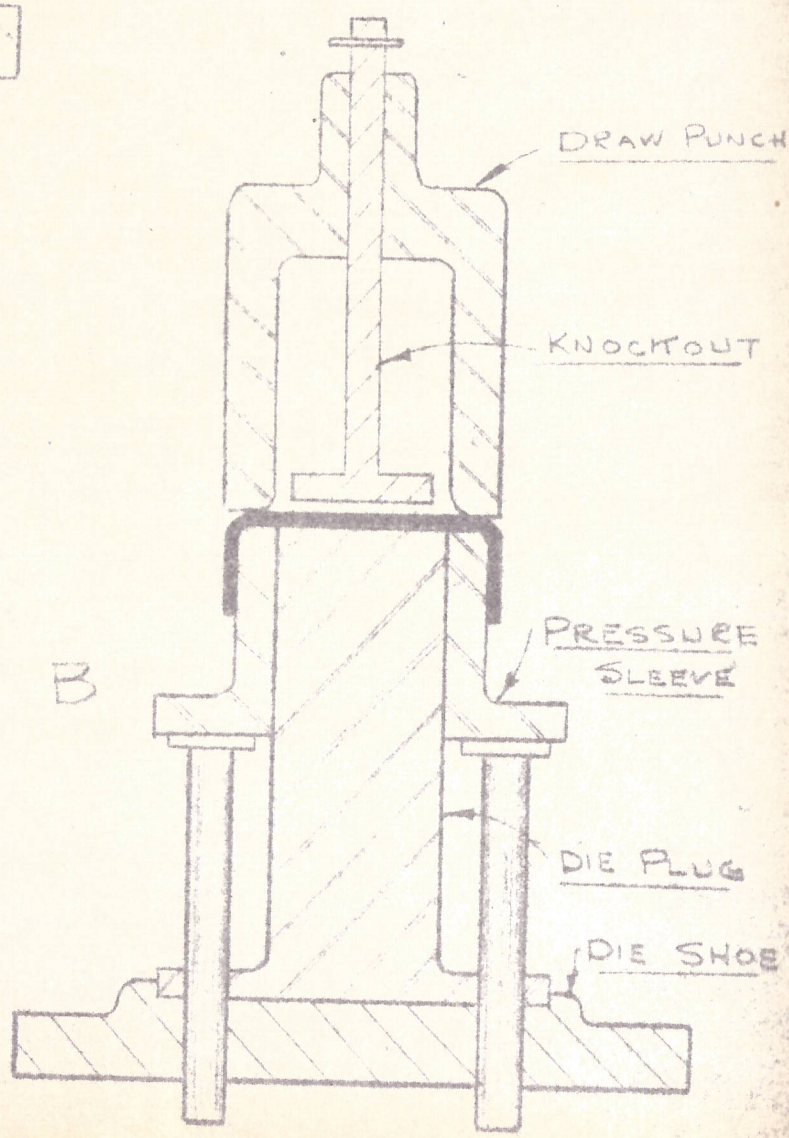
BLANK & DRAW TOOL

S.A TYPE

FIG. 8



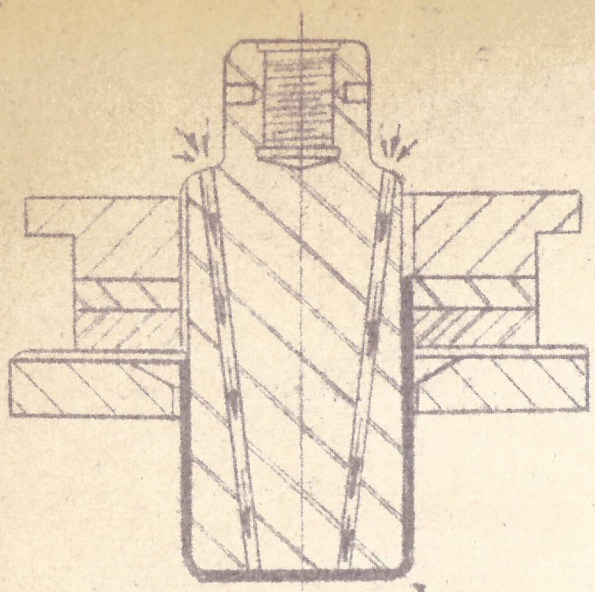
RE-DRAW TOOL DA TYPE



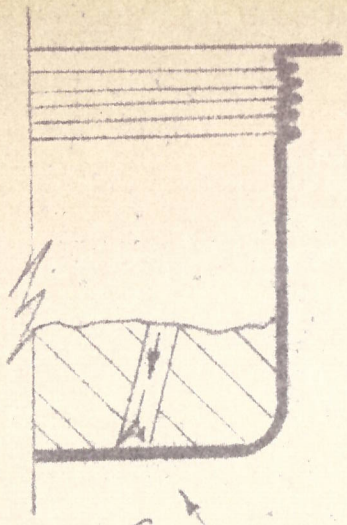
RE-DRAW TOOL S.A TYPE

RE-DRAW TOOLS

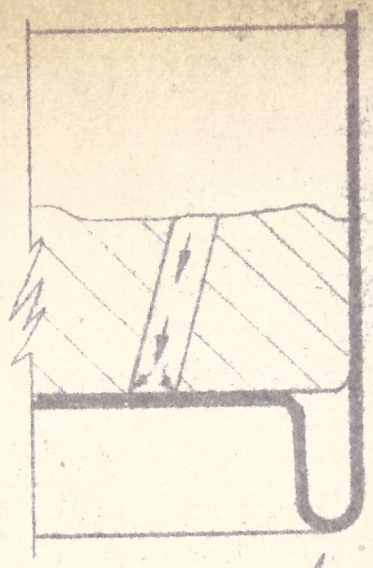
FIG. #9



A GOOD

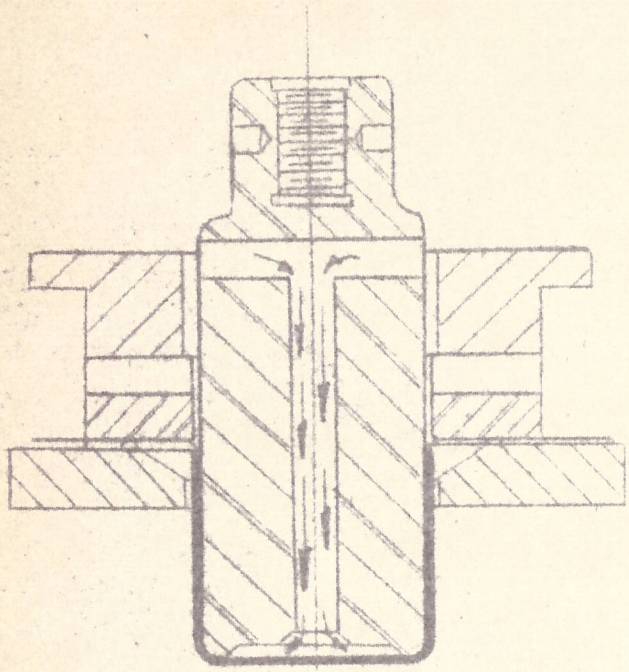


C

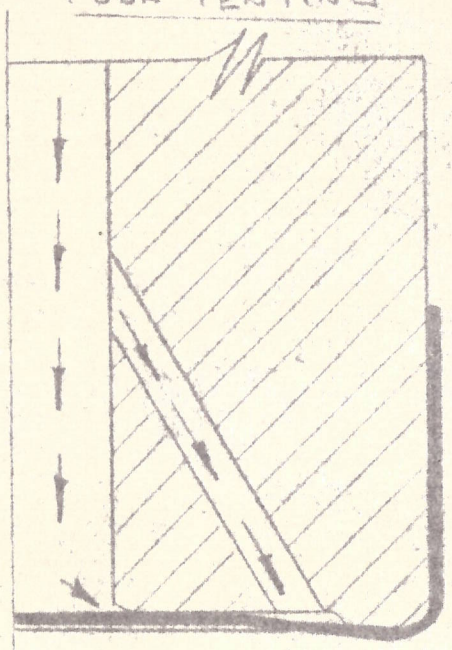


D

RESULTS OF POOR VENTING

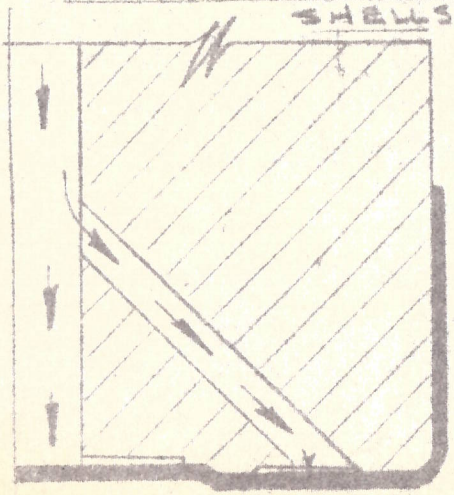


B BEST



E

TO AVOID TRAPPING OF AIR ON LARGE DIA SHELLS



F

VENTING

FIG #15

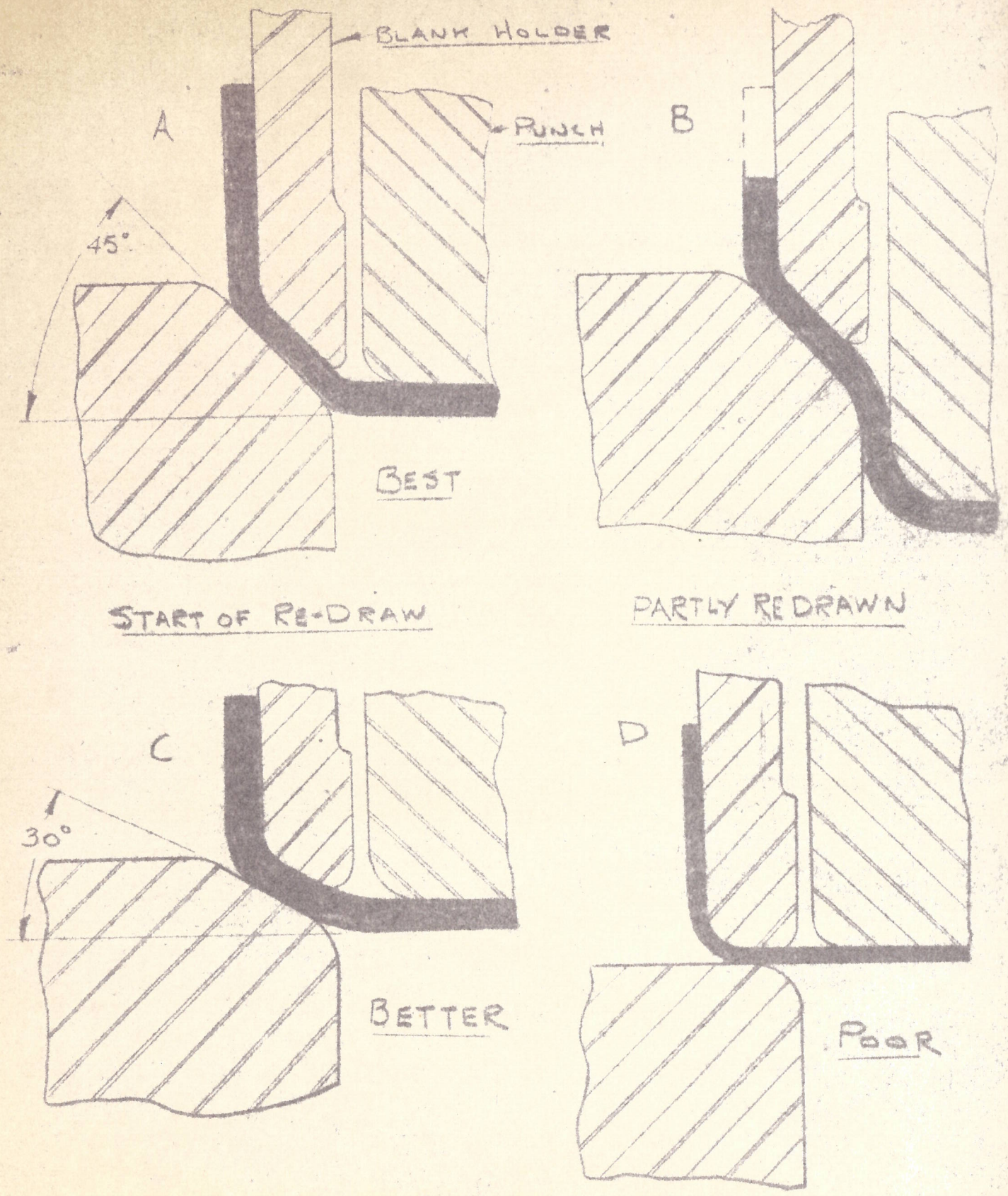
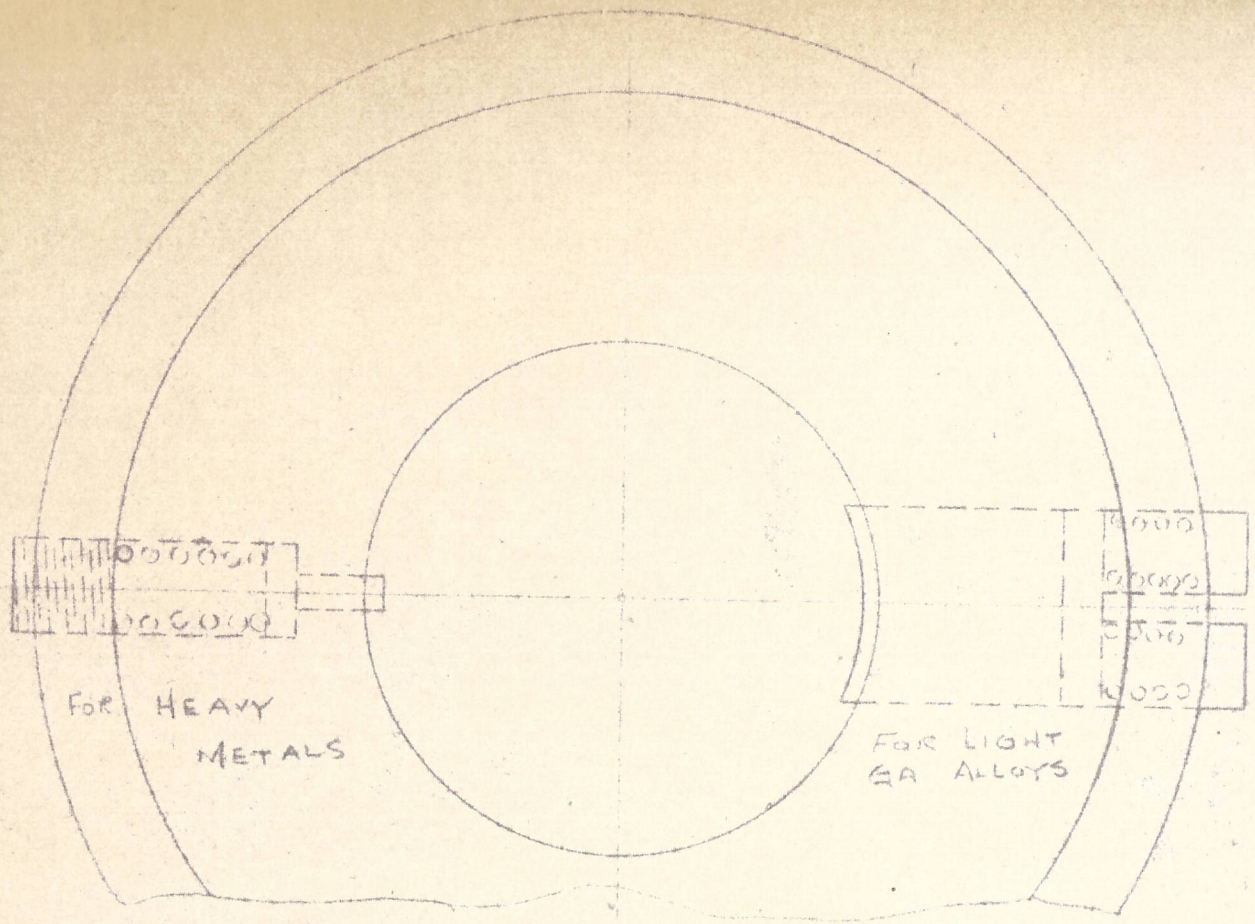
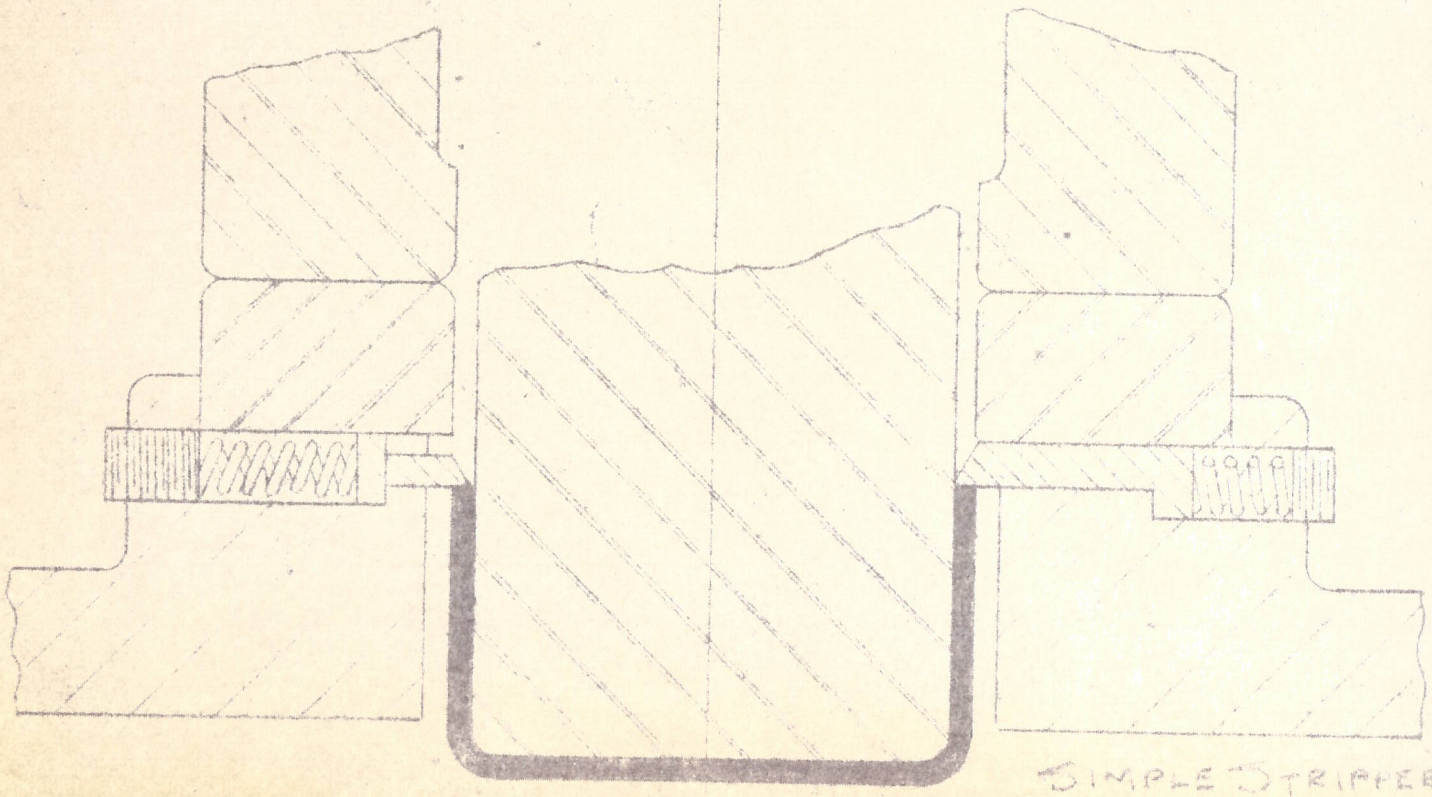

BLANK HOLDER
PUNCH
A
45°
BEST
START OF RE-DRAW
B
PARTLY REDRAWN
C
30°
BETTER
D
POOR

FIG-16

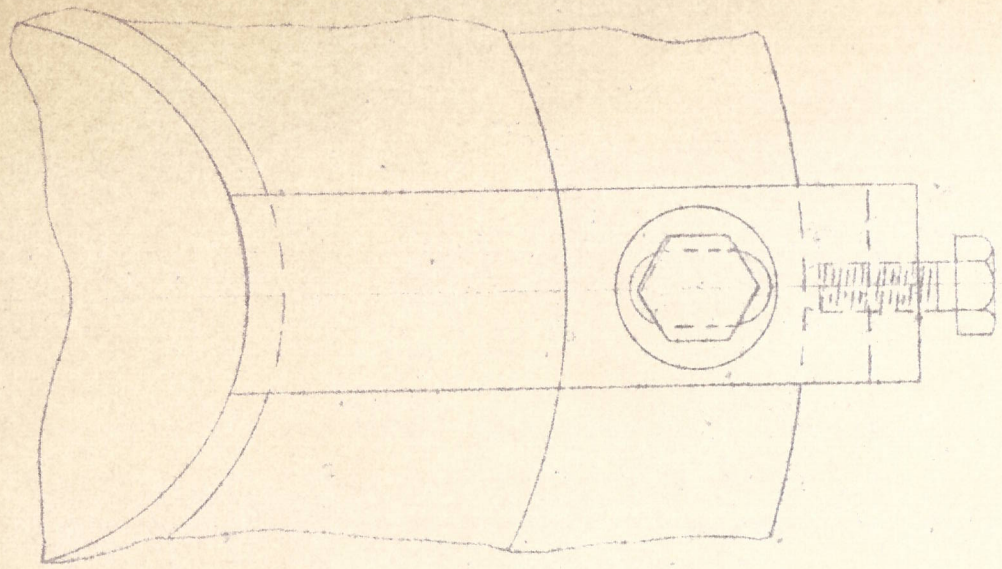


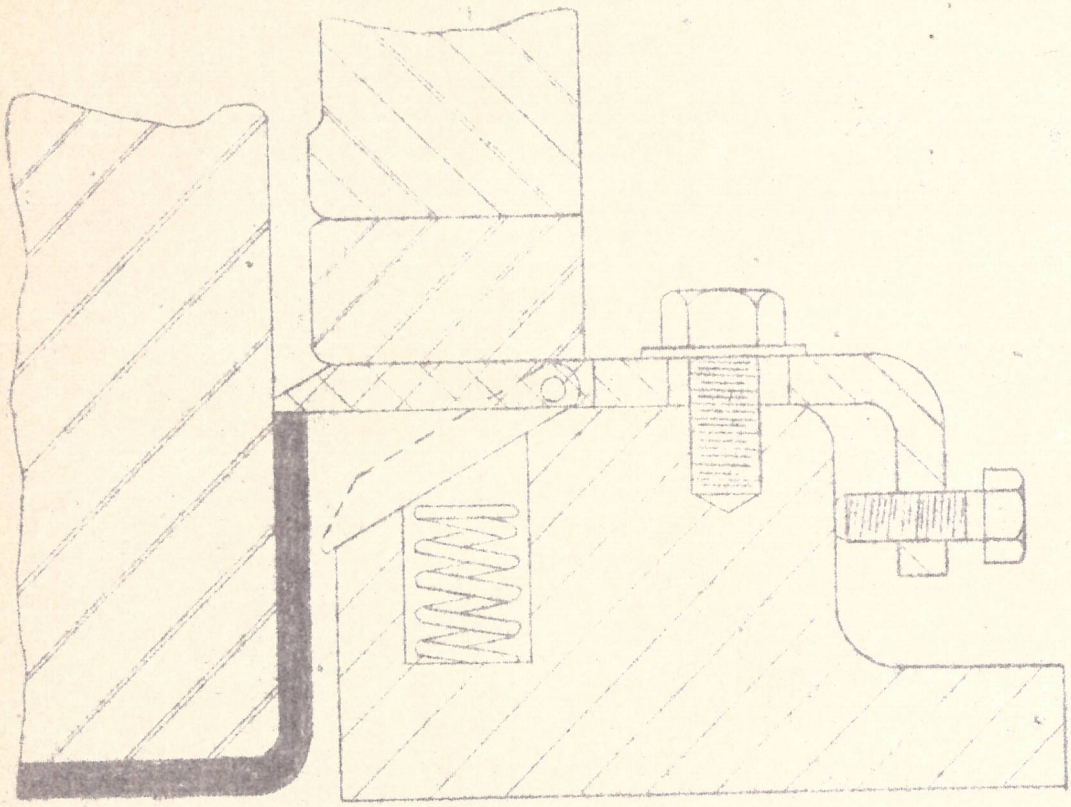
A

B



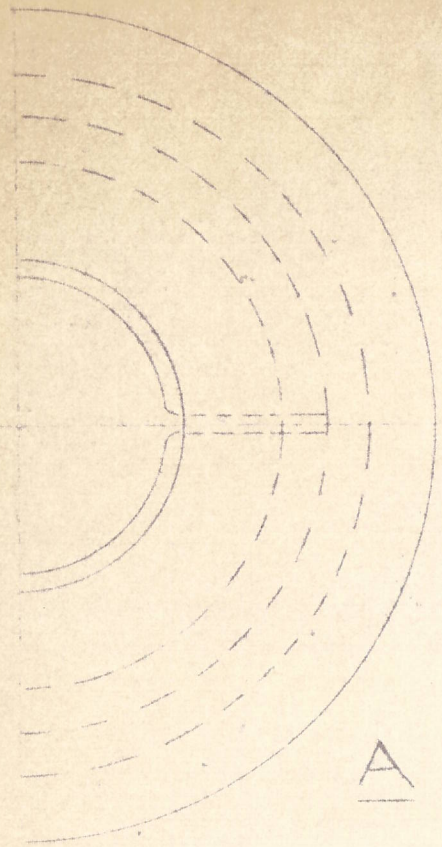
SIMPLE STRIPPERS

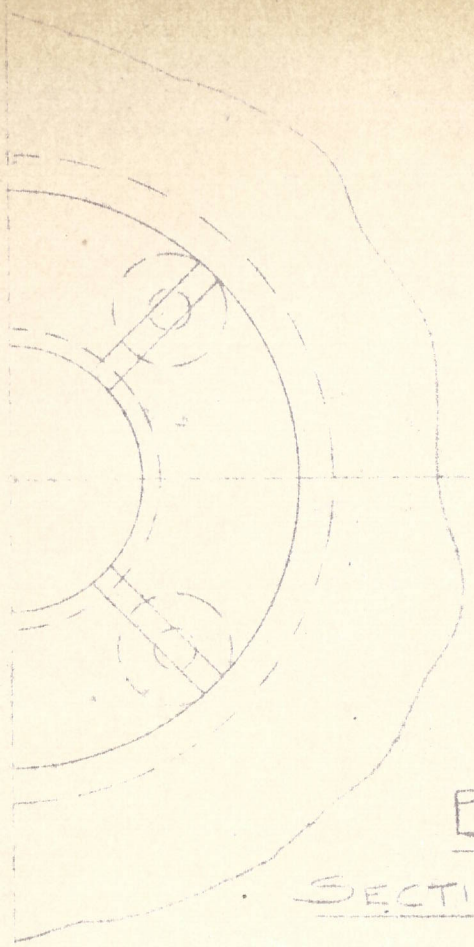




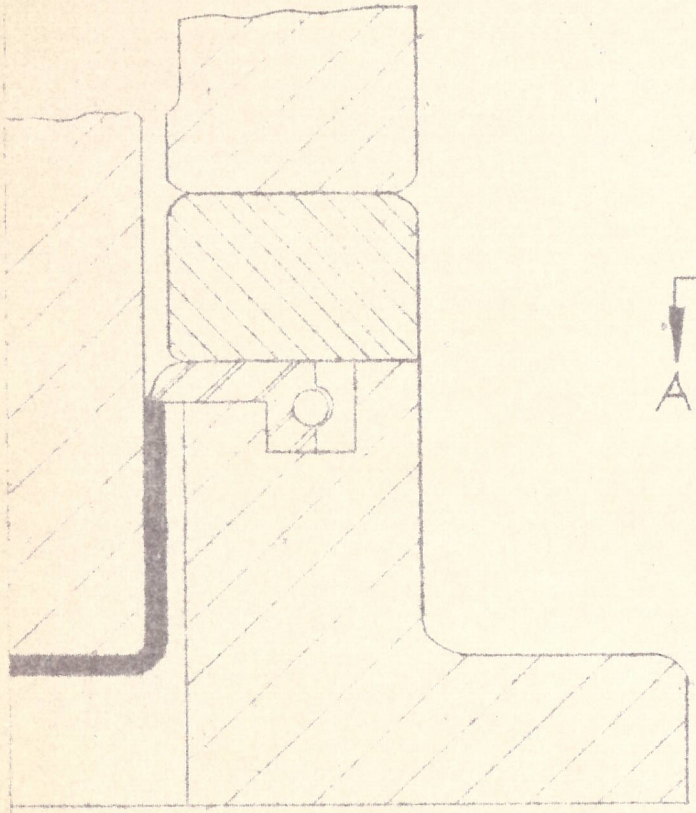
HINGE STRIPPER

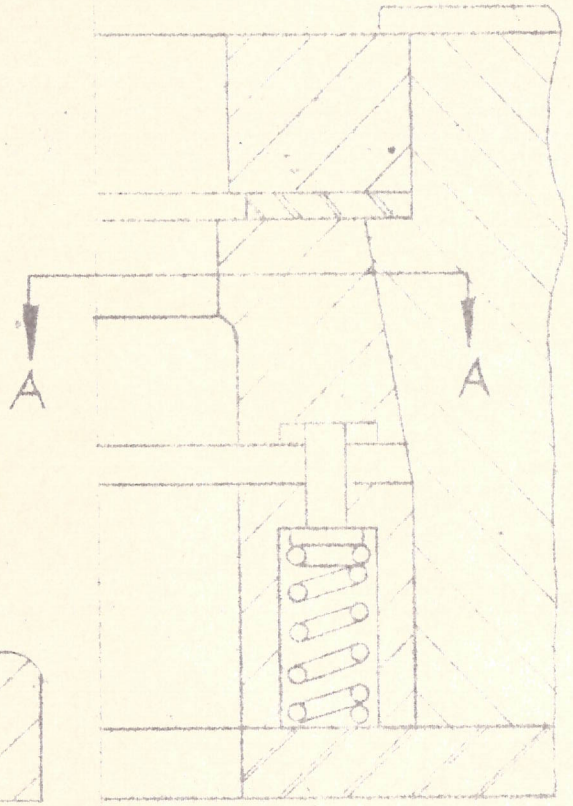
FIG #19





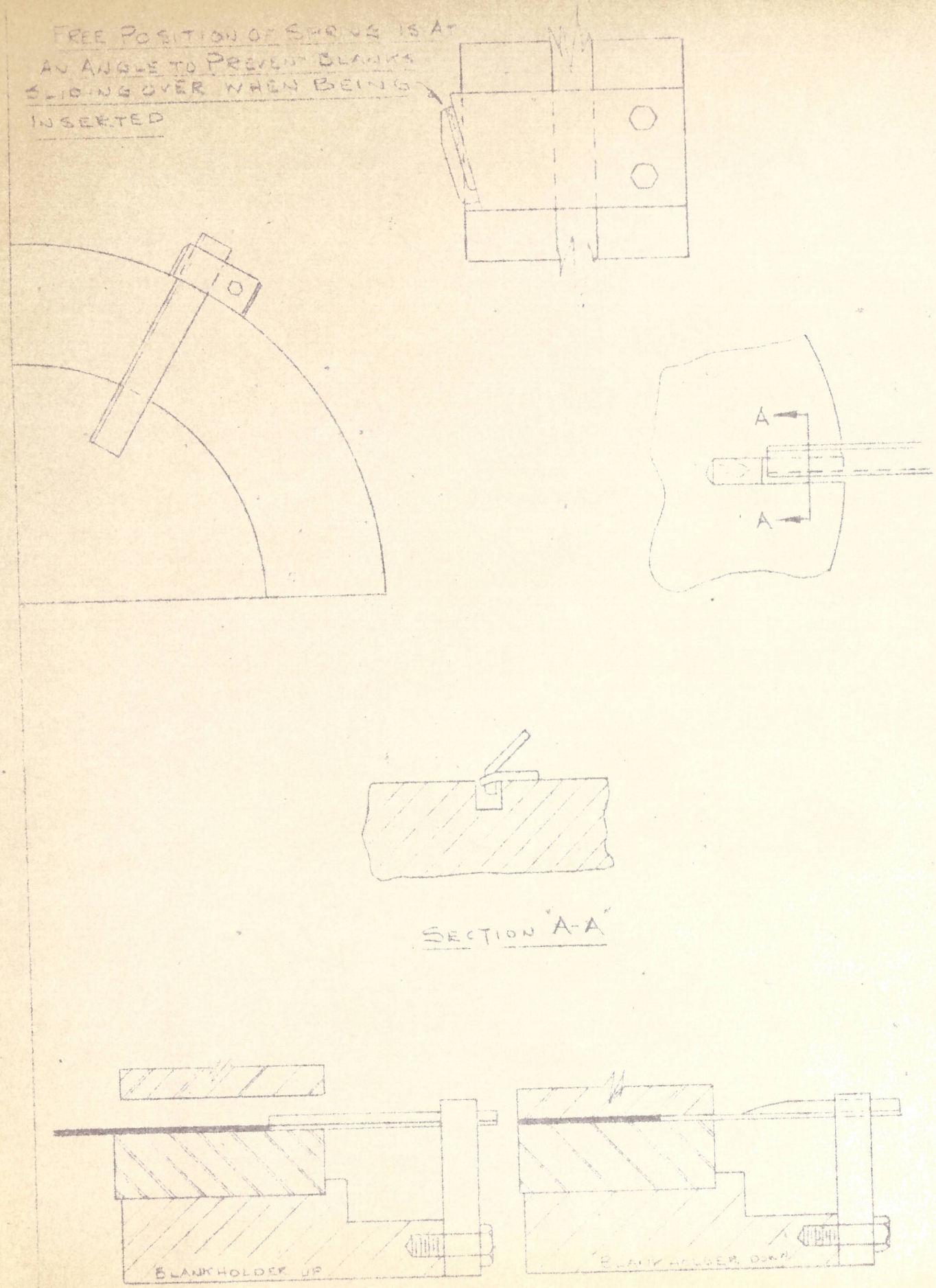
SECTION A-A





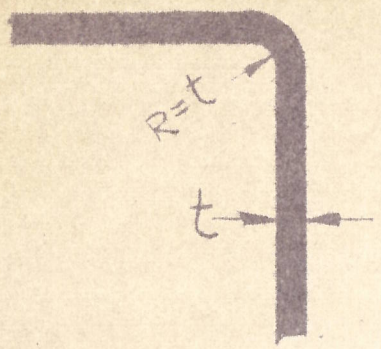
RING STRIPPERS

FIG 20

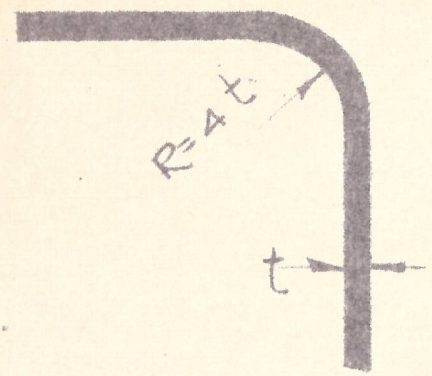


DETAIL OF ADJUSTABLE GAUGE FOR BLANKS FOR 1ST OPER. DRAW DIES

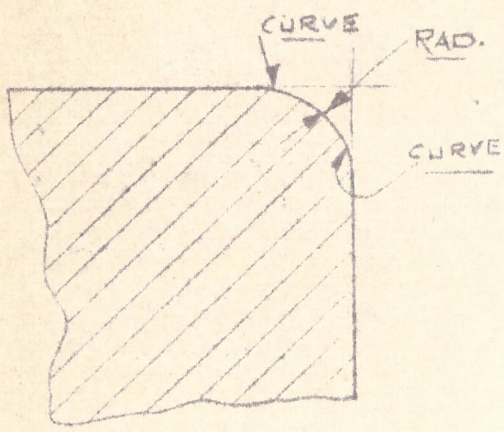
FIG 22



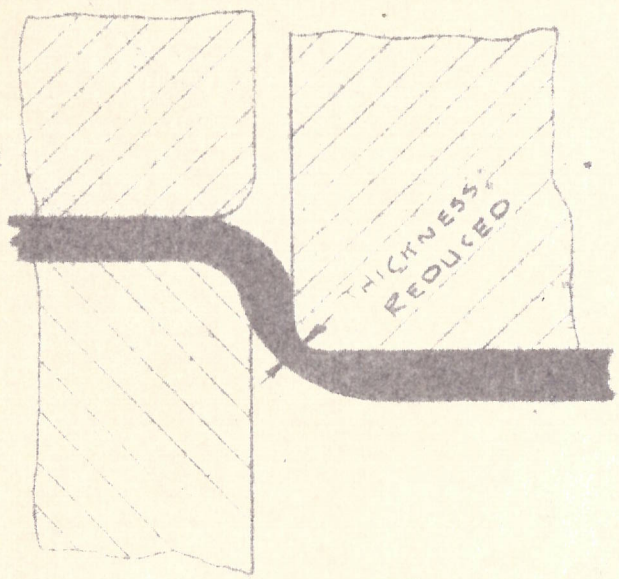
DRAW RADIUS TOO SHARP



NORMAL DRAW RADIUS ON DIE



BLENDED CURVES

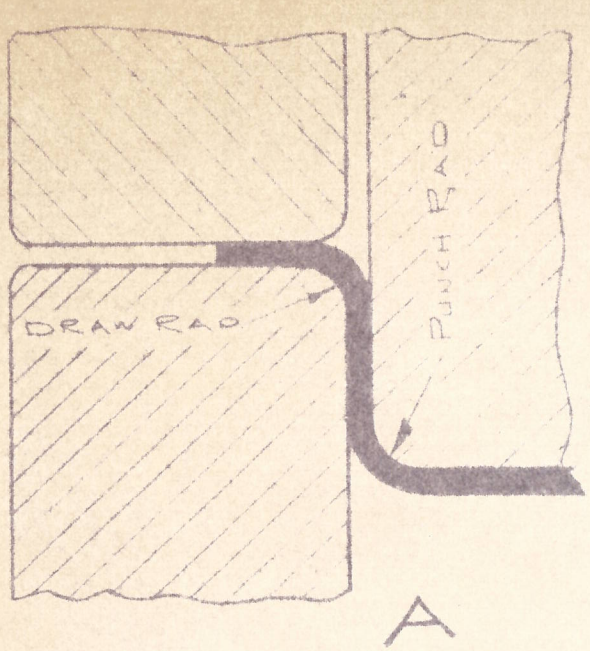


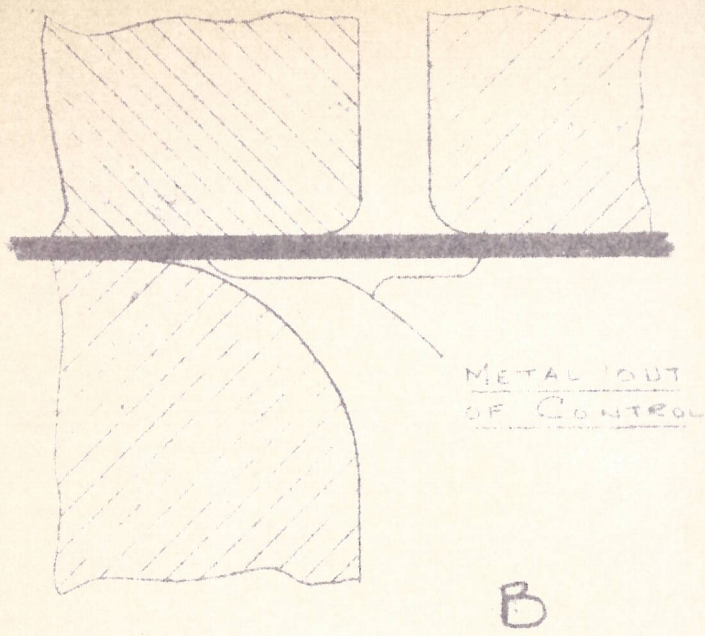
EFFECT OF TOO SHARP A RADIUS ON PUNCH

IF RADIUS MUST BE SHARP DRAW TO LARGE RADIUS AND SHARPEN IN LATER OPERATION

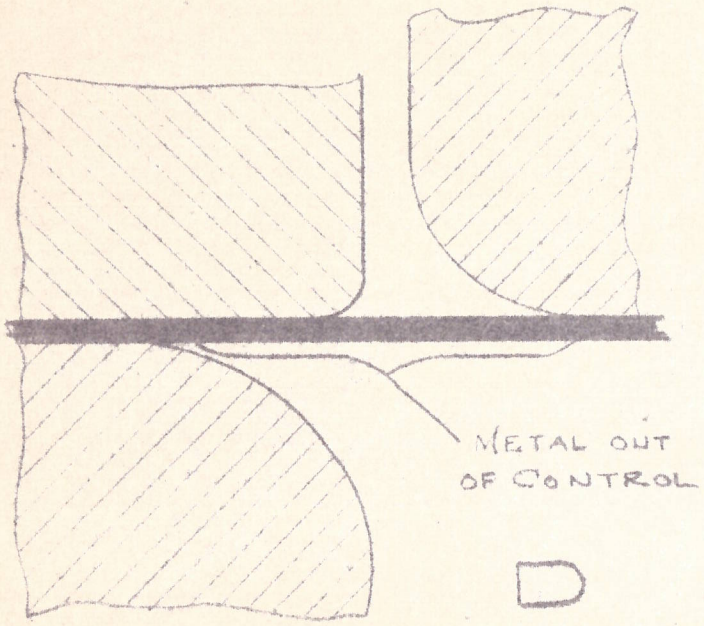
PUNCH AND DIE RADII

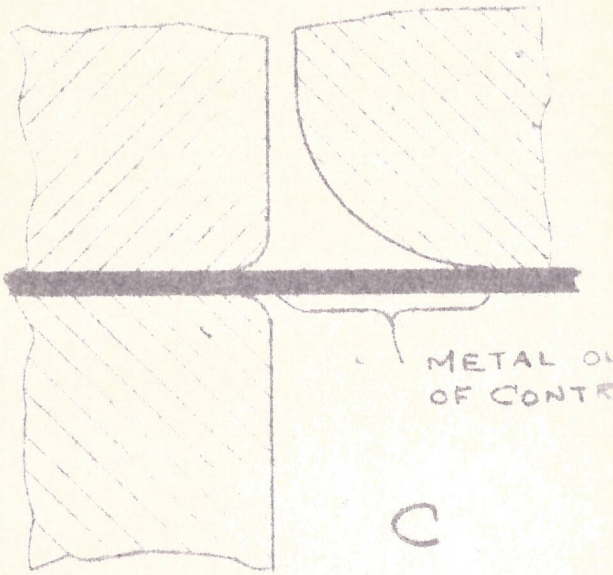
FIG 25





TOO LARGE A DIE RADIUS





TOO LARGE A RADIUS ON BOTH PUNCH & DIE

TO LARGE A PUNCH RADIUS

FIG 26

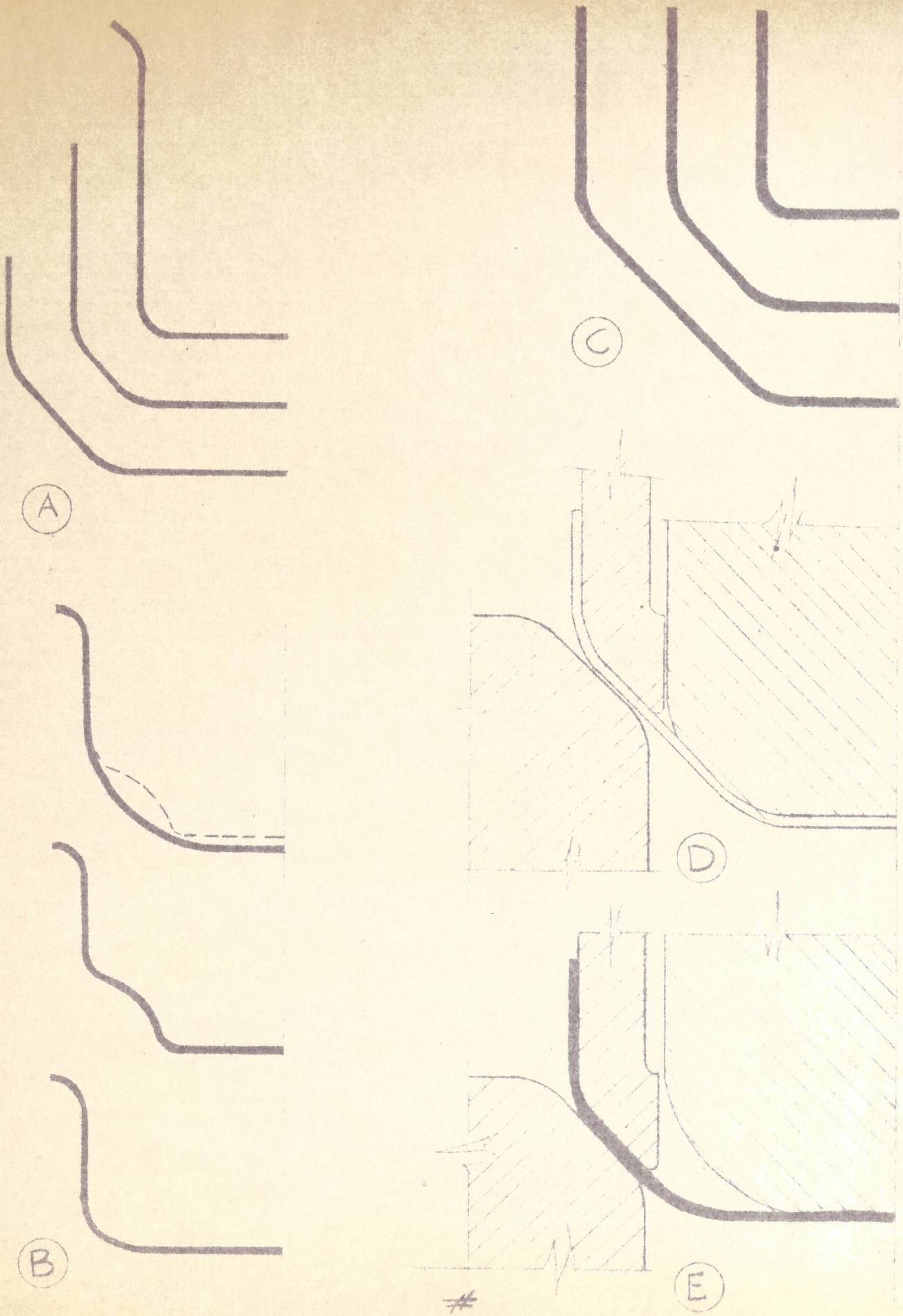
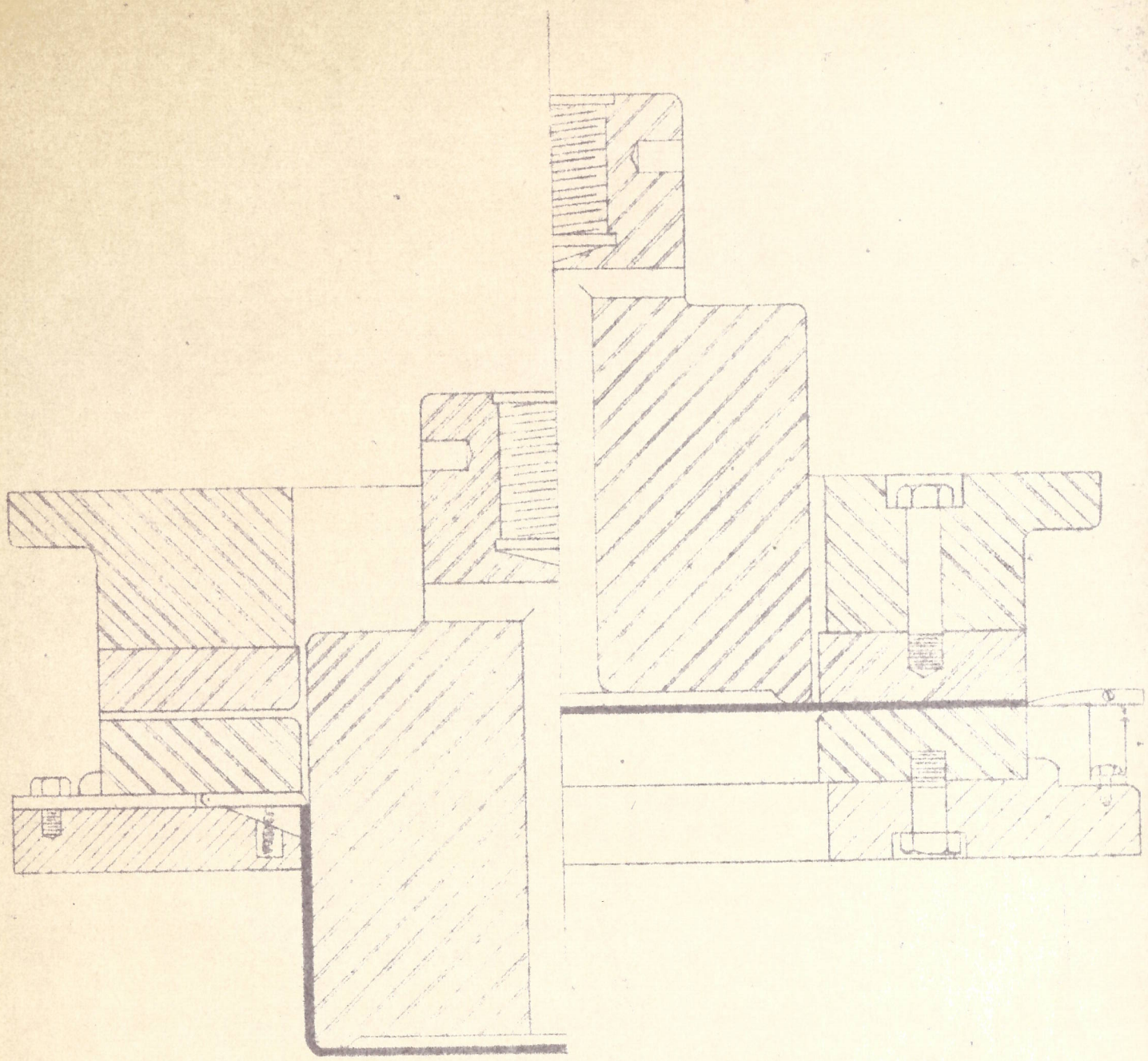


FIGURE 30

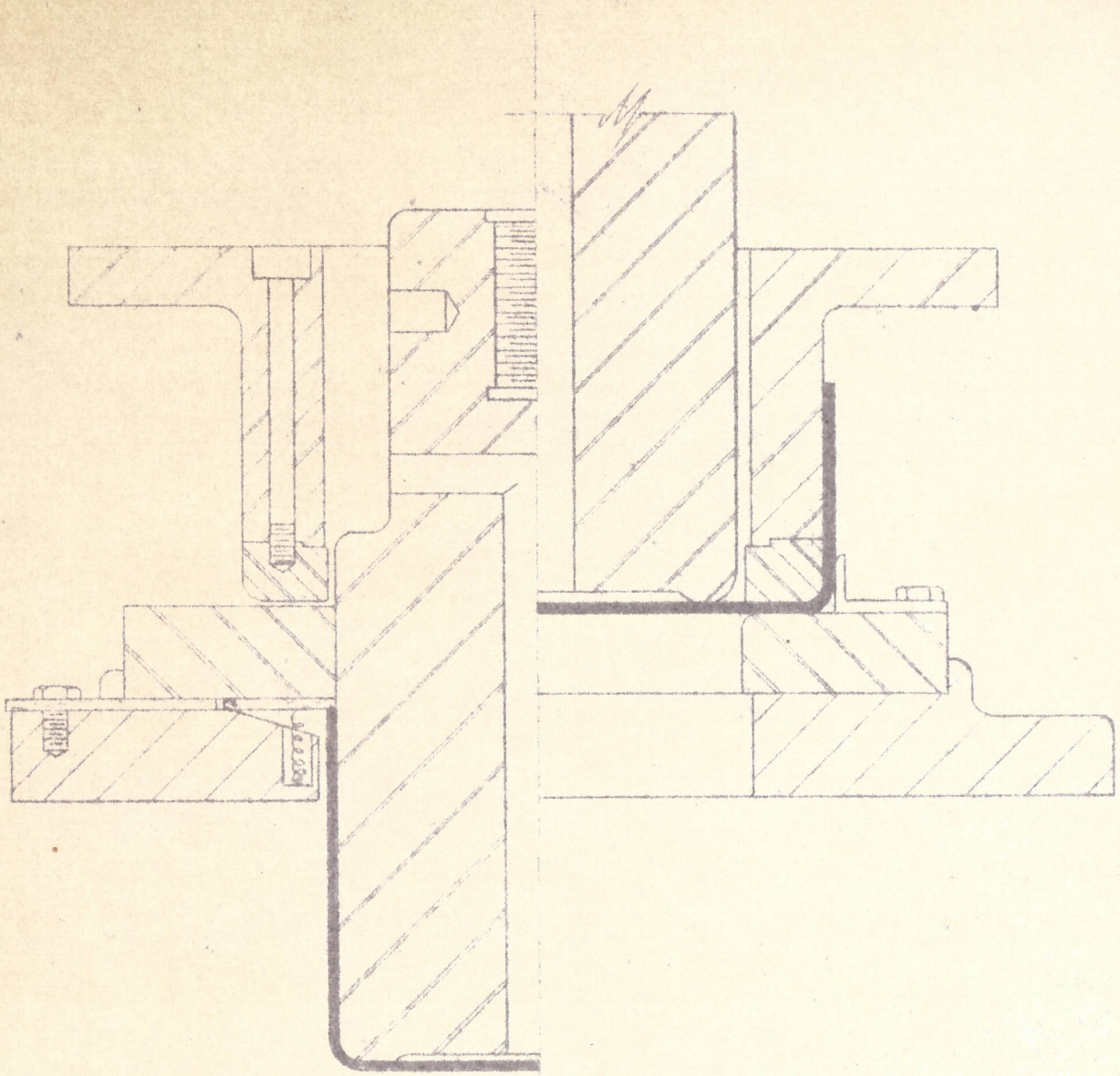


SCALE 4" = 1'-0"

TYPICAL FIRST OPER. DRAW DIE

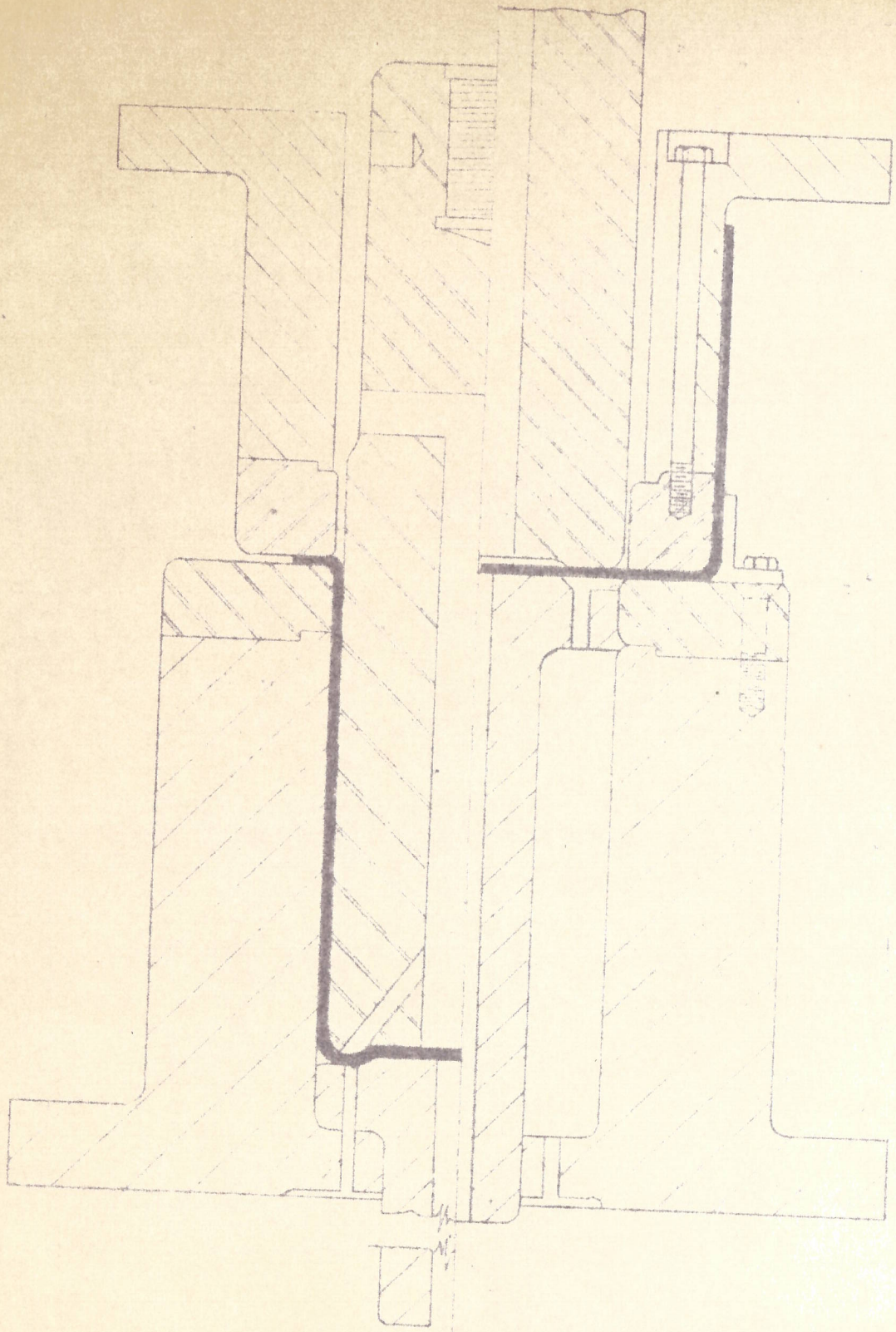
FOR LIGHT GAUGE ALUM SHELLS

FIG 31



TYPICAL REDRAW DIE
DRAW THRO' TYPE

FIG #32



TYPICAL REDRAW DIE
FOR SHELL WITH EMBOSSED BOTTOMS
OR FLANGED SHELL WHICH ARE TO BE REDRAWN

FIG 33

Lubrication of Work (for Drawing)

Suggested Lubricants: E.F. Houghton Products.

Steel (1) Hough to Steel Draw #36 - 20%
(Severe Soluble Oil - 60%
Draws) Water - 20%
Add a few ounces Cresylic Acid (8-10 ozs. to 5 gallons of mixture) to prevent toxic effect on workmen (rash)

(Severe (2) 50-50 Mixture of Nocut Base "A" and Forum #40
Draws)

(Light (3) Forum #40 (as supplied)
Draws) (4) Nocut Base "A" 25%
Forum #40 75%

(Drawing (5) Nocut Base "A" 80%) Imperial Oil
& Forum #40 20%) Products
Ironing)

(Heavy (6) Nocut Base "A" (as supplied)
Ironing)

BRASS

Draws (1) Houghton Draw #250 15%
Water 85%

(2) Graphite Arp. 10%
Tallow 90%

(Ironing) (3) Houghton Draw #TR 250 20%
Water 80%

ZINC: (1) Fullers Soap and Water (Hot)

ALUMINUM:

Light Draws. (1) Machine Oil Imperial
(2) Forum #46 Oil
(3) Amber Parmo #7 Products

Med. Draws. (4) Graphite in Soluble Oil
(5) Amber Petrolatum - Brit. - American
(6) Lard Oil

Severe Draws (7) 600 W (Car Wash and Oil)
(8) Kolnor Draw #78 (U.S. Import)
(9) 50-50 Mixture of (7) and (8) is good when delay is necessary between draws as KOLNOR #78 will dry out if used straight.

EXPANDING DIES

Whenever rubber is used as an expanding medium two important precautions must be observed:

(1) The rubber must be kept free of all contact with oil. (Oil attacks the rubber and in time reduces its bulk so that a full expansion cannot be obtained)

(2) Rubber and the shell must be lubricated with talcum powder or powdered pumice stone or some similar material in order to reduce the heat caused by friction (This heat burns the rubber and alters its expanding properties).

Tallow is a good expanding medium for tough jobs.

Time on rubber expanding and water expanding dies is about equal. Water expanding dies are two man jobs. Powder is sets applied in a tumbling barrel.

----------oOo----------

ESTIMATING JOBS.

(1) Is equipment suitable - capacity etc.?

(2) Would labour have to be specially trained - entailing lost time at start of production run? - no good on short run. What class of labour - wages?

(3) Will job demand cheap or expensive tools?

How many sets of tools required to complete run?

Will dies have to be nitrided or of carboloy for long runs? Automatic or manual stops and lubricating?

(4) Visualizing a job as to how many operations are required. Generally stick to well proven methods.

(5) Ensure that material specified by the customer is capable of being cold worked sufficiently to produce article. Will annealing be necessary. Suggest change in material if desirable. Material cost is usually 60 to 80% of total.

(6) Check design of product for possible simplification in collaboration with customer.

(7) Can scrap from blanks, slugs be salvaged or sold?

(8) After job has started to run, follow up from cost angle, finding which operations are losing money and which are making - thus assisting future estimates.

(9) Will it be one man job or [illegible]?

BOOKS

Metallurgy of Deep Drawing & Stamping by: [illegible] Chapman & Hall.

Plastic Working of Metals & Non Metallic Materials in Practice by: [illegible] Stone - Pitman Allen & Unwin.

Die Design & Die Making Practice by F.D. Jones, Industrial Press