centro de educación continua
división de estudios superiores
facultad de ingeniería, unam

A LOS ASISTENTES A LOS CURSOS DEL CENTRO DE EDUCACION CONTINUA

Las autoridades de la Facultad de Ingeniería, por conducto del Jefe del Centro de Educación Continua, Dr. Pedro Martínez Pereda, otorgan una constancia de asistencia a quienes cumplan con los requisitos establecidos para cada curso. Las personas que deseen que aparezca su título profesional precediendo a su nombre en la constancia, deberán entregar copia del mismo o de su cédula a más tardar el SEGUNDO DIA de clases, en las oficinas del Centro con la señorita Barraza, encargada de inscripciones.

El control de asistencia se llevará a cabo a través de la persona encargada de entregar las notas del curso. Las inasistencias serán computadas por las autoridades del Centro, con el fin de entregarle constancia solamente a los alumnos que tengan un mínimo del 80% de asistencia.

Se recomienda a los asistentes participar activamente con sus ideas y experiencias, pues los cursos que ofrece el Centro están planeados para que los profesores expongan una tesis, pero sobre todo, para que coordinen las opiniones de todos los interesados constituyendo verdaderos seminarios.

Es muy importante que todos los asistentes llenen y entreguen su hoja de inscripción al inicio del curso. Las personas comisionadas por alguna institución deberán pasar a inscribirse en las oficinas del Centro en la misma forma que los demás asistentes entregando el oficio respectivo.

Con objeto de mejorar los servicios que el Centro de Educación Continua ofrece, al final del curso se hará una evaluación a través de un cuestionario diseñado para emitir juicios anónimos por parte de los asistentes.

UNIVERSIDAD NACIONAL AUTONOMA DE MEXICO
FACULTAD DE INGENIERIA
DIVISION DE ESTUDIOS SUPERIORES
CENTRO DE EDUCACION CONTINUA
DIRECTORIO GENERAL

REGISTRO DE ASISTENTES Y PROFESORES.

NOMBRE DEL CURSO: ______________________ FOLIO ☐☐☐☐☐ (1 – 5) CLAVE ASOC. ☐☐ (6 7)

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TEL. PARTICULAR ☐☐☐☐☐☐☐ (59 – 65) TEL. OFICINA ☐☐☐☐☐☐☐ (66 – 72) EXTENSION ☐☐☐☐ (73 – 76)

MARQUE CON UNA CRUZ

ASISTENTE ☐ PROFESOR ☐ ☐ (77) 1 (80)

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FCEC-01

DISEÑO DE HERRAMENTAL

(del 9 de junio al 1º de julio de 1978)

FECHA	HORARIO	TEMA	PROFESOR
9 de junio	17 a 21 h	TROQUELADO Equipo para alta producción Equipo auxiliar Troqueles progresivos Troquelado económico Troquelado no tradicional	ING. VICTOR MANUEL RAMOS CATAÑO
10 de junio	9 a 14 h	EMBUTIDO Equipo para alta producción Herramentación Formación no tradicional Rechazado	ING. VICTOR MANUEL RAMOS CATAÑO
16 de junio	17 a 21 h	MAQUINADO Máquinas herramientas	ING. CARLOS PROAL MIRANDA
17 de junio	9 a 11 h	Máquinas de producción Automatización en 2a. operaciones	
17 de junio	11 a 14 h	FORMACION PLASTICA DE METALES Forja Equipo y herramentación Laminación Equipo y herramentación Extrusión Equipo y herramentación	ING. ULRICH SCHARER SAUBERLI

FECHA	HORARIO	TEMA	PROFESOR
23 de junio	17 a 21 h	METALURGIA EN POLVOS	ING. ULRICH SCHARER SAUBERLI
		Sinterización Equipo y herramentación	
		FUNDICION	
		En arena Equipo y modelos	
24 de junio	9 a 10 h	De precisión Equipo y modelación	ING. RAMON CUELLAR VRUN
		CLAUSURA	

'pmc.

DIRECTORIO DE PROFESORES

DISEÑO DE HERRAMENTAL

ING. RAMON CUELLAR VRUN
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AV. AZCAPOTZALCO No. 398 LOCAL 1
COL. AZCAPOTZALCO
MEXICO 16, D.F.
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ING. CARLOS PROAL MIRANDA
GERENTE GENERAL
HERRAMIENTAS E INSTRUMENTOS DE MEDICION, S.A.
AV. MORELOS No. 50
MEXICO 1, D.F.
TEL: 512. 30. 27 y 521. 90.81

ING. VICTOR MANUEL RAMOS CATAÑO
DIRECTOR DEL TALLER MECANICO
PHILCO, S.A.
LAGO ALBERTO No. 380
COL. SANTA MARIA LA RIBERA
MEXICO 4, D.F.
TEL: 547.46.00 ext. 153 y 587. 03. 91

ING. ULRICH SCHARER SAUBERLI
DIRECTOR TECNICO
CIERRES REX, S.A.
FERROCARRIL ACAMBARO, TOLUCA No. 24
NAUCALPAN DE JUAREZ, EDO. DE MEXICO
TEL: 575. 38. 33

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EVALUACION DE LA ENSEÑANZA

CURSO: DISEÑO DE HERRAMENTAL

FECHAS: del 9 de junio al 1º de julio de 1978

PROFESOR Y/O TEMA	DOMINIO DEL TEMA	EFICIENCIA EN EL USO DE AYUDAS AUDIOVISUALES	MANT. DEL INTERES (AMENIDAD, FACILIDAD DE EXPRESION, COMUNICACION CON LOS ASISTENTES)	PUNTUALIDAD
1.- TROQUELADO Ing. Víctor Manuel Ramos Cataño				
2.- EMBUTIDO Ing. Víctor Manuel Ramos Cataño				
3.- MAQUINADO Ing. Carlos Proal Miranda				
4.- FORMACION PLASTICA DE METALES Ing. Ulrich Scharer Sauberli				
5.- METALURGIA EN POLVOS Ing. Ulrich Scharer Sauberli				
6.- FUNDICION Ing. Ulrich Scharer Sauberli				
7.- FUNDICION. De precisión. Equipo y modelación Ing. Ramón Cuéllar Vrun				
ESCALA DE EVALUACION DEL 1 AL 10 'mag. 29.VI.77				

EVALUACION DEL CURSO

	CONCEPTO	EVALUACION
1.	APLICACION INMEDIATA DE LOS CONCEPTOS EXPUESTOS	
2.	CLARIDAD CON QUE SE EXPUSIERON LOS TEMAS	
3.	GRADO DE ACTUALIZACION LOGRADO CON EL CURSO	
4.	CUMPLIMIEN TO DE LOS OBJETIVOS DEL CURSO	
5.	CONTINUIDAD EN LOS TEMAS DEL CURSO	
6.	CALIDAD DE LAS NOTAS DEL CURSO	
7.	GRADO DE MOTIVACION LOGRADO CON EL CURSO	

ESCALA DE EVALUACION DE 1 A 10

1. ¿Qué le pareció el ambiente del Centro de Educación Continua?

Muy agradable ☐ Agradable ☐ Desagradable ☐

2. Medio de comunicación por el que se enteró del curso:

Periódico Excélsior ☐	Periódico Novedades ☐	Folleto del Curso ☐
Cartel mensual ☐	Radio Universidad ☐	Comunicación carta, teléfono, verbal, etc. ☐

3. Medio de transporte utilizado para venir al Palacio de Minería:

Automóvil particular ☐ Metro ☐ Otro medio ☐

4. ¿Qué cambios haría usted en el programa para tratar de perfeccionar el curso? ____

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____

5. ¿Recomendaría el curso a otras personas? Si ☐ No ☐

6. ¿Qué curso le gustaría que ofreciera el Centro de Educación Continua? ____

____

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7. ¿Qué servicios desearía que tuviese el CEC para los asistentes a cursos? ____

____

____

8. Otras sugestiones:

____

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DISEÑO DE HERRAMENTAL

TROQUELADOS

Y

EMBUTIDO

ING. VICTOR MANUEL RAMOS.

JUNIO ,1978.

TROQUELADO

El trabajo en lámina se ha desarrollado extensamente desde a principios de siglo por países industrializados, teniendo un papel muy importante en la industria manufacturera. A travez del tiempo, los requerimientos de diseño han obligado a los acereros, a producir lámina que ofrezca una calidad y características que satisfagan estos requerimientos en donde la plasticidad, elasticidad y la resistencia, cumplan su cometido en la fabricación de partes cada vez más complicadas .

La Industria en los Estados Unidos del Norte de América, ha desarrollado muchas aleaciones de diferentes características que nos proporcionan una gama suficiente para satisfacer hasta ahora las necesidades del diseño del producto y que las ha normalizado (AISI) .

El trabajo de la lámina más complejo y por ende el que requiere de mayor técnica e ingenio, es el troquelado . El troquelado es la acción de deformar racionalmente una lámina aprovechando la fuerza de una prensa troqueladora y utilizando en una herramienta ó troquel que le da la forma deseada, aprovechando las características del material antes descritas . Esta es la forma tradicional, aunque se ha desarrollado otras técnicas como el troquelado quimico, que ya veremos en otro capítulo .

Los troqueles producen piezas económicas e iguales que pueden ser intercambiables, característica indispensable de la Industria Moderna .

El troquelado puede ser punzonado, cizallado, doblado, estampado y embutido, éstas son operaciones básicas, aunque hay herramientas que combinan una ó más de estas características .

PUNZONADO :

El punzonado es una operación mécanica que consiste en perforar una lámina en forma predeterminada de una manera instantánea .

Esta operación se desarrolla aprovechando la propiedad del acero de transformación plástica. Todas las operaciones del troquelado en general, se desemvuelven alderredor de este fenómeno .

La transformación que sufre la lámina al ser cortada, se describe en la Figura 1 .

Como lo demuestra la figura 1 el material sufre antes de ser cortado, una deformación elástica, ya que las fibras del mismo tienden a estirarse progresivamente conforme el punzón va penetrando, al rebasarse el límite de elasticidad, se cortan las fibras y la parte cortada se recupera rápidamente, ésto provoca que el tejo cortado se apriete a la matriz y el mismo sea expulsado cuando efectúe otra operación de corte .

....//....

Así también la lámina se adhiere al punzón de ahi que se requieren elementos que desprendan la lámina del punzón .

La práctica nos aconseja la siguiente regla :

El diámetro mínimo que podemos troquelar sin poner en peligro de ruptura al punzón, es el mismo espesor del material, ya que la resistencia al corte es superior a la del punzón .

Esto se refiere a lámina rolada en frío de troquelado normal y punzones templados, sí el material cambia de características se puede mejorar esta condición .

Las matrices deberán de tener una salida de material y esto obedece a que después de ser cortada la primera pieza y recuperarse, se queda fija a las paredes de la matriz, al troquelar la segunda pieza, ésta empuja a la primera, pero también se adhiere a las paredes de la matriz, éstos esfuerzos se van sumando y si nó le damos una salida adecuada a la matriz, se rompera inutilizandose definitivamente .

Hay tres maneras de dar salida a las matrices Figura 2 .

a.- A partir de la misma arista del corte. Así se hace cuando trabajamos metales blandos como aluminio, latón, plomo, cobre etc. pero también es usado cuando las matrices van a producir altas cantidades de piezas. En los troqueles para producir laminación de motores es muy popular esta salida .

b.- Dejando una parte recta a partir de la arista de corte con una profundidad de dos ó tres veces el espesor del material cortado .

Este sistema se aplica en matrices destinada a metales duros como acero rolado en frío con perfiles exactos .

c.- Dejando una parte recta a partir de la arista de dos ó tres veces el espesor del material y después de este nivel, una cavidad no cómicasino siguiendo la forma de la matriz más grande apróximadamente de 0.78 mm. (1/32 ") . Esta forma es más rápida de construir pero en algunas ocasiones un poco peligrosa, pero puede usarse en troqueles de baja producción .

JUEGO ENTRE PUNZON Y MATRIZ :

Este factor tiene uan importancia decisiva en la precisión de las piezas punzonadas, además de la perfección con que se ha construido el troquel, también se le conoce por holgura y es la sobre medida que le damos a la matriz para que el corte sea bueno y no deje rebaba.

Sin embargo la holgura puede darse en el punzón, depende en donde se requiera la medida crítica .

Cuando la holgura se ha dado correctamente, podemos observar en el canto cortado una superficie pulida brillante, que no debe de ser mayor de la tercera parte del espesor del material y las dos terceras partes arrancado . Sí la holgura no ha sido suficiente, la superficie cortada es pulida y brillante casi en la totalidad del espesor del material observandose pequeños arillos como cuarteduras y produce rebaba al final del corte, provoca mucha fricción en el punzón que puede ser causa de un desgaste prematuro y en otros casos de roturas.

El exceso de holgura se caracteriza por una franja redondeada al penetrar el punzón, después una pequeña franja pulida y el resto arrancado produce rebaba. Ver figura 3 .

En la figura No. 4 podemos observar en donde podemos dar la holgura correcta .

Como se observa se trata de una rondana en donde el diámetro interior debe tener una medida determina así como el diámetro exterior .

Como el tejo que se saca para dar el diámetro interior es despreciable ó rebaba, la holgura la damos en la matriz, pero al punzonar el diámetro exterior el tejo es lo que nos interesa, la holgura la daremos en el punzón.

Esta regla se debe aplicar siempre ; cuando la figura va a quedar en la lámina que está encima de la matriz, la holgura se aplica a la matriz, sí la figura que se troquela sale de la matriz despreciandose el material que queda sobre la superficie de la matriz, la holgura se da en el punzón .

La tabla 1 les da valores a diferentes espesores y materiales de las holguras adecuadas.

....#....

Tabla 1.- Tolerancias Admisibles Entre Punzones y Placas

Espesor Del Mat. m/m	Juego entre matriz y punzón			
	Latón y acero dulce	Acero medio duro	Acero Duro	Aluminio
0,25	0,01	0,015	0,02	0,02
0,5	0,025	0,03	0,035	0,05
0,75	0,04	0,045	0,05	0,07
1	0,05	0,06	0,07	0,10
1,25	0,06	0,075	0,09	0,12
1,50	0,075	0,09	0,10	0,15
1,75	0,09	0,10	0,12	0,17
2	0,10	0,12	0,14	0,20
2,25	0,11	0,14	0,16	0,22
2,50	0,13	0,15	0,18	0,25
2,80	0,14	0,17	0,20	0,28
3	0,15	0,18	0,21	0,30
3,3	0,17	0,20	0,23	0,33
3,5	0,18	0,21	0,25	0,35
3,8	0,19	0,23	0,27	0,38
4	0,20	0,24	0,28	0,40
4,3	0,22	0,26	0,30	0,43
4,5	0,23	0,27	0,32	0,45
4,8	0,24	0,29	0,34	0,48
5	0,25	0,30	0,36	0,50

PRESIONES REQUERIDAS PARA EL PUNZONADO :

El punzón en el instante en que penetra, inicia su acción de compresión e inmediatamente después el corte ó punzonado. En todo el perímetro comprimido,es ejercida una presión contínua por parte del punzón y la reacción que se opone al esfuerzo aplicado por parte del material. El punzón sigue bajando hasta que la presión con que ataca es superior a la resistencia al corte del material .

Cuando se cortan las fibras de éste, es cuando la pieza esta cortada, pero en el supuesto caso de que el punzón dejara de bajar, la recuperación eléstica del material fuertemente adherida al contorno del material seccionado, va a formar una estructura única. Por lo que el punzón debe salir del espesor del material para asegurar que la pieza está cortada .

Para calcular cuanto tonelaje requerimos para punzonar una lámina, es muy importante conocer que resistencia al corte en Kg / mm2 ó libras/ Pulg.2 dependiendo el sistema que usemos .

La resistencia al corte de láminas de acero rolado en frío que usamos normalmente son de 40 Kg/mm2 ó 50 000 libras/Pulg.2

....#....

De manera que la formula es para el sistema inglés :

$$P = \frac{S \times e \times Ks.}{2000} \quad ó \quad S \times e \times 25$$

P = Presión

S = Perímetro por cortar ó longitud de corte

Ks= Resistencia al corte

E = Espesor del material

Ejemplo :

¿ Cuantas toneladas se requerirán para punzonar un agujero redondo de 3/4 " en una lámina de acero rolado en frío de .047 " de espesor ?

$S = .750 \times 3.1416 = 2.3562$

$E = .047$ "

$Ks = 50.000$

$$P = \frac{2.3562 \times .047 \times 50.000}{2000}$$

$P = 2.76$ Ton.

La fórmula para el sistema métrico es :

$$P = S \times e \times Ke$$

P = Presión requerida en Kg.

S = Longitud de corte

E = Espesor del material

Ke = Resistencia al corte

Ejemplo :

¿ Cuantos Kg. se requerirán para punzonar un agujero de 19.05 de diámetro en una lámina de acero rolada en frío de 1.19 mm. de espesor ?

S = 19.05 x 3.1416 = 59.847448

E = 1.19

Ke = 40 Kg./mm2

P = 59.847448 x 1.19 x 40

P = 2848 Kg. = 2.84 Ton.

Ejercicio :

1.- ¿ Cuanto tonelaje se requerirá para punzonar una rondana en que su diámetro exterior tiene 1'' su diámetro interior 11/16 en acero rolado en frío de .035 '' de espesor ?

Respuesta .- P =

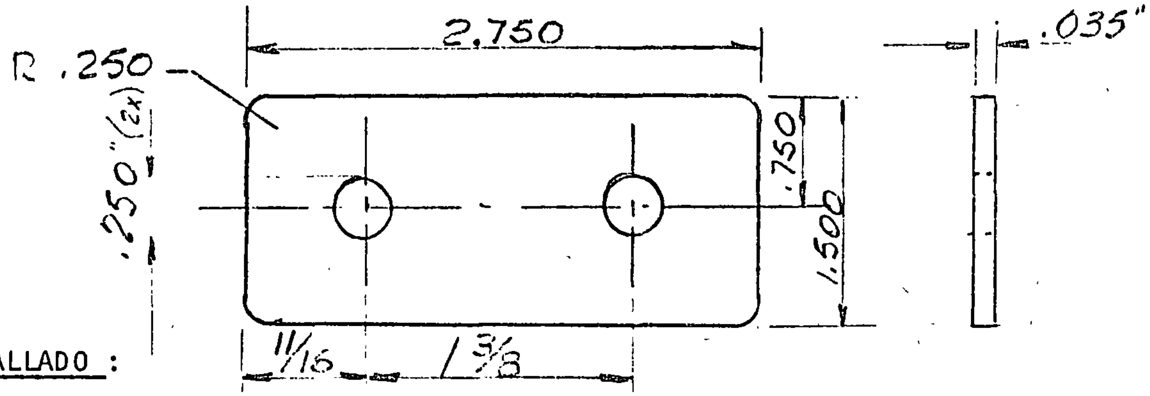
....#....

2.- ¿ Cuantos kilogramos se requerirán para punzonar un agujero rectangular de 15 mm x 27 mm. en acero rolado en frío de 1.19 mm. de espesor ?

Respuesta .- P =

3.- ¿ Cuantas toneladas se requerirán para cortar una pieza de forma rectangular de 1.5" x 2.75 " y en cada esquina tiene un radio de .250 " además de dos agujeros de .250 " de ∅ en su interior?

La lámina empleada es rolada en frío de .035 " de espesor .



CIZALLADO :

El cizallado es la operación de cortar la lámina partiendo que el punzón ó la cuchilla de corte tiene un ángulo de 10 ° aunque en algunos casos la matriz puede estar fabricada con ángulo .

En la figura 5 tenemos 6 maneras diferentes de cortar cizallando .

Este método puede ahorrar un 50 % aproximadamente de la fuerza que se requiera para cortar una longitud determinada en método de corte plano. En distancias de menos de 200 mm. suele deformar la lámina por lo que se usa generalmente para cortes lineales grandes y existen máquinas especiales para estos cortes que se llaman cizallas ó guillotinas .

La fórmula para cálcular el esfuerzo del corte es :

$$A = P \times S$$

$$S = L \times \text{Tang}$$

$$A = P \times S \times \text{Tang.} \alpha$$

$$P = \frac{e2 \quad x \quad Ke}{2 \text{ Tang } \alpha}$$

e = Espesor del material

Ke= Resistencia al corte en KG / mm2

x = Angulo de corte 10 °

L = Longitud por cortar

Ejemplo :

Cálcularemos el tonelaje requerido para cortar 76.2 Cm. de longitud en una lámina de 1.19 mm. tanto plano como con ángulo de 10°.

De la primera fórmula obtenemos :

$P = S \times e \times Ke$

$P = 76.2 \times 1.19 \times 40$

$P = 3.627$ Ton.

$$P = \frac{e2 \times Ke}{2 \text{ Tang } \alpha} = \frac{1.4161 \times 40}{2 \; (0.15838)} = \frac{56.644}{0.31676}$$

$P = 178.823$

$A = P \times L \times \text{Tang} \alpha$

$A =$ 2.158 Ton.

59 % menos tonelaje

DOBLADO :

La operación de doblado consiste en variar la forma de una lámina sin modificar el espesor, de modo que todas las secciones secesivas sean iguales .

Siendo el doblado mucho más sencillo que el embutido, es de recomendar que antes de determinar la forma final de una pieza, es conveniente estudiar si pudiera usar solamente dobleces y no mediante la operación de embutido.

Para realizar la operación de doblar se requiere equipo especialmente diseñado para esta operación, ya que en una prensa común para punzonar es muy rápida y no permite una deformación de las fibras adecuadas, lo que puede ocasionar resorteo (Spring Back) ó rotura de la cara exterior del doblez .

Claro que un doblez pequeño se puede realizar en una prensa rápida máxime cuando ésta operación está incluida en un troquel que también corta.

Obviamente la calidad del material quiere decir mucho, lo mismo que ciertas condiciones que debe de reunir el troquel .

El esfuerzo requerido para doblar una lámina a 90°, está determinado por la fórmula :

$$P = \frac{e \times Ke \times L \times D}{3\ L}$$

e = Espesor del material

Ke= Resistencia al corte en Kg / mm2

L = Longitud del doblez

D = Distancia del apoyo de la lámina

Ejemplo :

¿ Cuanto tonelaje se requiere para doblar una lámina rolada en frío de 1.19 mm de espesor para una longitud de 1.5 Mts. y usando un dado de 25.4 mm entre apoyos ?

Respuesta .-

$$P = \frac{e \times Ke \times L \times D}{3\ L} = \frac{1.19 \times 40 \times 1500 \times 25.4}{4500}$$

P = 403 Kg.

Ejercicio :

¿ Cuanto tonelaje requerimos para doblar una lámina rolada en frío de - 0.93 de espesor para una longitud de .5 Mts. con un dado de 19.05 entre apoyos ?

¿ Cuanto tonelaje requerimos para doblar una lámina rolada en frío de 3.17 mm. de espesor para una longitud de 1.219 Mts. con dado de 50.8 - entre apoyos ?

Hay diferentes tipos de dados dobladores y los venden estándarizados ver figura 6 , aunque los dobleces se pueden hacer en forma combinada con- elementos giratorios ver figura 7 .

CALCULO DE DESARROLLOS :

Este es un capítulo importante para que a partir de una pieza doblada, - podamos cálcular el tamaño de la misma pieza antes de ser doblada, es decir su desarrollo .

El desarrollo se cálcula tomando en cuenta una tercera parte del espesor del material aunque también se puede tomar la fibra neutra, los resultados tienen muy poca diferencia como más adelante veremos, Las partes rectas de la pieza se toman como son y no sufren alargamiento, en la figura 8 podemos ver una lámina doblada a 90° en donde se ve claramente la fi -

bra neutra y las partes rectas . Sí a la figura 8 le damos dimensiones podemos cálcular su desarrollo de la siguiente manera :

$$P = \frac{3.1416 \times D}{4}$$

$$0 = .500 + .500 + .047$$

$$D = 1.047$$

$$P = \frac{3.1416 \times 1.047}{4} = .822''$$

$$DES = 1.250 + 1.500 + .822 = 3.575$$

Sí calculamos ésta misma pieza por el método de tomar en cuenta 1/3 del espesor del material, la fórmula es :

$$DES = 1.57 \ (.3 \times T + r)$$

T = Espesor del material

r = Radio interior

Substituyendo

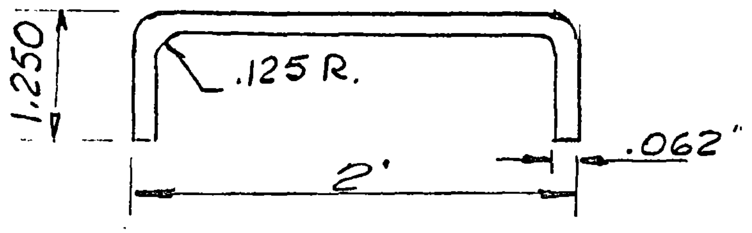
$$D = 1.57 \ (.4 \times .047 + .500)$$

$$0 = .814$$

$$DES.\ Total \ 1.250 + 1500 + .814 = 3.564$$

En la práctica éste método es más preciso que el anterior y el recomendable además de ser el más popular en los Estados Unidos de Norte - América.

Para aplicar estas fórmulas calculemos el desarrollo de la figura 9



Por el método de la fibra neutra calcularemos el desarrollo anterior :

Ejercicio :

1.- Calcular el desarrollo de la siguiente pieza por los dos métodos :

EL EMBUTIDO

El término embutido no responde exactamente al fenómeno ó grupo de fenómenos que experimentan los materiales cuando aprovechando sus cualidades plásticas, se les somete a un proceso de deformación en el cual se parte de una lámina plana.

La palabra embutido se escogió por la remota semejanza que existe entre el procedimiento mecánico y la acción de rellenar con exceso un recipiente con una materia moldeable, adquiriendo la forma de aquel .

La acción primaria y fundamental consiste en el alargamiento del plano neutro, que tiene como consecuencia la inmediata deformación del mismo . La operación del embutido ó estirado consiste generalmente en transformar una lámina plana de metal, en un cuerpo de revolución ó prismático procediendo gradualmente mediante una ó varias operaciones .

Con el simple proceso del embutido, el espesor del material laminado no debe variar, de lo cual se deriva que la superficie de la pieza debe ser " Teóricamente " igual a la de la superficie desarrollada, sin embargo , en la práctica no ocurre esto con exactitud.

Es interesante que nos adentremos un poco para estudiar el comportamiento real de las fibras cuando se encuentran sometidas a un proceso de embutición, en la figura 10 podemos observar que un disco de diámetro " D " , ha sido sometido al proceso de deformación para obtener un recipiente cilíndrico de diámetro d y una altura h .

En el disco trazamos el diámetro d que es la base del recipiente que se quiere obtener y determinamos una superficie S ó sector trapesoidal, como lo hemos trazado utilizando un rayador, una serie de radios que están formando una serie de líneas convergentes ó divergentes, y en estas condiciones sometemos la plantilla a embutir, los trazos formarán una serie de líneas paralelas tal como se índica en la figura 10 es decir, la superficie S de forma trapesoidal,ha sufrido una variación durante el proceso transformandose en la rectangular S . Como consecuencia de tal fenómeno, hemos de deducir que el elemento durante la embutición, ha sufrido dos esfuerzos uno radial de tracción y otro tangencial de compresión , debido a tal cambio la dimensión h de la plantilla se ha transformado en la h mayor debido al alargamiento producido en las fibras por el efecto tracción compresión a que ha estado sometida la lámina, y al someter ésta al embutido se ve que a medida que ésta progresa, las líneas radiales se vuelven paralelas conforme el material pasa alderredor del radio de la matriz de embutido .

....#....

Si se traza un elemento rectangular y se le somete a un proceso de embutido, el metal es comprimido en las aristas verticales pero también es estirado en aristas horizontales produciendose un reacomodo en la unión de las dos aristas muy enérgico donde los radios que se han diseñado para el producto, son muy importantes de manera que si son adecuados, no tendremos problemas para obtener un recipiente rectangular .

El estiramiento de la lámina adecuado, lo podemos obtener apoyandonos en un elemento importantísimo que es el planchador que nos presenta un estirado de cizallamiento puro, suponiendo que las cargas de tracción y compresión sean iguales a pesar de que ésta condición ideal es difícil de alcanzar en el proceso de embutido, es posible acercarse a ella hasta un punto que permite mucho mayores alargamientos que los normales .

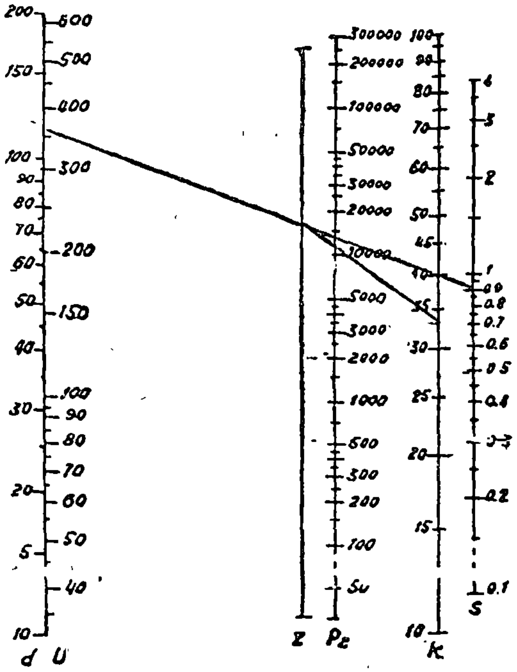
El embutido de lámina con planchador, es un proceso conocido y muy desarrollado en muchas de nuestras industrias .

El planchador tiene como misión pisar la lámina con presión adecuada de manera que no se formen arrugas, ya que una vez que se formó la arruga , no se puede eliminar pero ésta presión no debe ser excesiva, ya que puede provocar la ruptura del material al sufrir una estirada drástica .

En las figuras 11, 12 y 13, mostraremos el comportamiento de un troquel-embutidor donde el macho está penetrando por la acción de la prensa y donde el planchador controla la fluidez del material ayudado por los lubricantes especiales para este caso,así como su superficie de manera que se le permita al material la transformación adecuada .

Para calcular la presión que se requiere para embutir una pieza cilíndrica, se usa entre otros el siguiente diagrama :

Figura 14 .



— Determinación de la presión de embutido P_z

....#....

Se une por medio de una recta el punto que representa el valor del diámetro del punzón <u>d</u> ó el de su circunferencia <u>U</u> con el grueso del material <u>S</u> y en el punto de corte la línea auxiliar <u>Z</u> unido, a su vez con el que representa el resultado de multiplicar la resistencia a la tracción K2 por el coeficiente <u>M</u> , que como tenemos en la tabla que a continuación mostramos, como ya se dijo anteriormente, depende de la relación de estirado D/d ; la intersección con la escala P2 nos proporciona la presión necesaria.

D/d	0.55	0.60	0.65	0.70	0.75	0.80
m	1.0	0.86	0.72	0.60	0.50	0.40

La relación D/d es la relación que existe entre el diámetro interior de la pieza y el diámetro del desarrollo y <u>M</u> es un Coeficiente que depende de la relación d/D .

$D = \sqrt{d2 + 4dH}$

d = Ø del Recipiente

H = Altura del Recipiente

Ejemplo :

Se requiere calcular el diámetro de la lámina para embutir una pieza cilíndrica de 120 mm Ø por 50 mm. de altura y espesor de .093 , aplicando la fórmula obtenemos :

$D = \sqrt{d2 + 4dH}$

$D = \sqrt{120^2 \times 4 \; (120 \times 50)}$

$D = \sqrt{14400 + 24000}$

$D = \sqrt{38400}$

D = 195.95

Sí dividimos $\frac{D}{d} = \frac{195.95}{120} = 0.612 \therefore m \approx 0.86$

Con estos datos y aplicando el diagrama de la figura 14 obtenemos :

Unimos el punto de la línea d el diagrama de 120 con el espesor del material y trazamos una recta, por otro lado obtuvimos el resultado de m = 0.86 que multiplicado por 40 que es la resistencia a la tracción , nos da 34.4 localizamos este punto en la línea K y lo unimos con el punto de intersección de la primera línea con la línea Z y a la intersección de la línea P podemos leer 12 Ton. apróximadamente.

Si aplicamos la fórmula :

$$P = \pi \times d \times s \times m \times K2$$

De donde

d = Diámetro del cilíndro

s = Espesor del material

m = Al coeficiente D/d

K2= Esfuerzo a la tracción

Obtenemos :

$P = 3.1416 \times 120 \times .93 \times .86 \times 40$

$P = 12.060$ Ton.

Ejercicio :

Calcular el tonelaje requerido para embutir una pieza cilíndrica de 85 mm Ø por 27 mm. de altura y espesor de .88 mm. según fórmula .

Calcular el tonelaje requerido para embutir una pieza cilíndrica de 170 mm Ø x 90 mm. de altura con un espesor de 1.57 mm.

Como determinar el desarrollo :

El problema que significa determinar la cantidad de lámina que usaremos para embutir una pieza es relativamente fácil si la pieza es regular, ya que los desarrollos se calculan teóricamente basados en fórmulas muy experimentadas, sin embargo aún así la exactitud no es rigurosa, sino depende del estirado que sufran las paredes de las piezas por embutir .

Es verdad que el embutido es una deformación sin variación plástica sin variación de espesor , pero en la práctica no sucede así, alterando, por lo tanto el alargamiento experimentado por el material, así como también las condiciones de ductibilidad en que se encuentra el material, nos hacen recomendar que calcularemos teóricamente el desarrollo y proveemos con estos datos y de acuerdo a los resultados obtenidos en la operación .

Procedemos a corregir nuestro desarrollo con mayores posibilidades de éxito.

La fórmula que utilizaremos para determinar el desarrollo de una pieza cilíndrica será :

$$\sqrt{d2 + 4dH}$$

d = Diámetro exterior

H = Altura del embutido

Ejemplo :

¿ Cual será el desarrollo de un recipiente que tiene el diámetro exterior de 110 mm. y una altura de 68 mm. ?

$$D = \sqrt{110^2 + 4 (110 \times 68)}$$

$$D = \sqrt{12100 + 4 (7480)}$$

$$D = \sqrt{12100 + 29920}$$

$$D = \sqrt{42020}$$

$$D \sim 20498$$

Ejercicio :

¿ Cual será el desarrollo de un recipiente cilíndrico de diámetro exterior de 85 mm. x 35 mm. de altura ?

Para calcular desarrollos de piezas embutidas rectangulares ó cuadradas ver figura 14 , solamente calculamos como dobles la sección longitudinal y transversal de acuerdo con la altura que se requiera, una vez obteniendo el largo y el ancho de la lámina, unimos los puntos exteriores de la plantilla en las esquinas y tenemos un desarrollo muy apróximado para la fabricación de este recipiente .

Para desarrollos de piezas embutidas de forma irregular por medios teóricos, es muy difícil y no se han encontrado fórmulas adecuadas, sin embargo nuestra recomendación, es determinar por los métodos conocidos la superficie de la pieza, para trazar una plantilla teórica ligeramente mayor al cálculo obtenido y someterla al troquel de embutido, no sin antes hacer un duplicado para futuras correcciones .

Después del embutido obtenemos las verdaderas necesidades de la plantilla para agregar ó quitar donde lo requiera a la plantilla que tenemos de reserva, y así después de dos ó tres intentos obtendremos nuestra plantilla .

Regresando a los desarrollos de piezas cilíndricas en la figura 15 , tenemos una tabla de algunos desarrollos que nos pueden auxiliar en la determinación de figuras parecidas ó iguales .

Secuencia de operaciones para trabajos de embutidos.

Algunas piezas embutidas son muy altas con relación a su diámetro para lograr obtener este embutido, es necesario recurrir a varios pasos, ya que de una sola operación no sería posible porque el material no aguantaría la estirada tan brusca y se fracturaría .

Las piezas que se pueden embutir de un solo golpe, son aquellas cuya profundidad es igual a la mitad del diámetro, tratandose de piezas grandes, solamente pueden embutirse cuya altura sea un tercio del diámetro de las mismas.

Si las piezas tienen más altura de lo que hemos dicho anteriormente, requieren de más operaciones de embutido.

Para calcular el No de embutidos que se requieren para terminar una pieza, aplicaremos la siguiente fórmula :

$$N = \frac{m}{e}$$

$m = \frac{h}{d}$

d = Diámetro de la pieza

h = Altura de la pieza

e = 1/2 para piezas pequeñas hasta 130 mm.

e = 1/3 para piezas grandes más de 130 mm.

Ejemplo :

Calcular el No. de operaciones que se requieren para embutir una pieza de 55 mm Ø x 118 mm. de altura .

Aplicando la fórmula :

$$N = \frac{m}{e}$$

Tenemos :

$$m = \frac{h}{d} = \frac{118}{55} = 2.14$$

Substituímos : $N = \frac{2.14}{1/2} = 4.28$

Es decir requerimos 4 operaciones para sacar la pieza .

Cálculemos cada una de las operaciones :

El desarrollo del disco se determina aplicando la fórmula :

$$D = \sqrt{d2 + 4dh}$$

$$D = \sqrt{55^2 + 4 (55 \times 118)}$$

DE DONDE

$$D = \sqrt{3025 + 25960}$$

$$D = \sqrt{28985}$$

$$D \sim 170$$

La profundidad del primer embutido será $h = \frac{d}{2}$ siendo h = Altura de la pieza embutida y d el diámetro de la misma . La fórmula $D = \sqrt{d2 + 4dh}$ se puede escribir así, $D2 = d2 + 4dh$ substituyendo el valor de h por su valor $\frac{d}{2}$ se obtiene :

$$D2 = d2 + 4d \frac{d}{2} = d2 + 2d2 = 3d2$$

$$D2 + 3d2 \quad \text{de donde} \quad D = 3d2 \quad D = 1.73\ d$$

$$d = \frac{D}{1.73} = \frac{170}{1.73} = 98.26 \text{ mm de diámetro}$$

$$h = \frac{1}{2} d = \frac{98.26}{2} = 49.1 \text{ mm de altura}$$

Para el segundo paso tenemos que procediendo análogamente como en la primera operación, pero teniendo que $h_1 = d$ (Al valor $h = \frac{1}{2} d$ se le agrega otro medio) .

Entonces se obtiene :

$$D = \sqrt{5\,d_1} = 2.23\,d_1$$

$$d_1 = \frac{D}{2.23} = \frac{170}{2.23} \quad 76.23 \ \varnothing$$

$$h = d_1 \quad 76.23$$

Para el tercer paso procedemos de la misma manera pero $h2 = \frac{3}{2}\,d2$ (al valor de $h_1 = d_1$ se le agrega otro medio entonces se obtiene)

$$D = \sqrt{7\,d2} = 2.64\,d2$$

$$d2 = \frac{D}{2.64} = \frac{170}{2.64} \sim 64.39$$

$$h2 = \frac{3}{2}\,d2 = \frac{3}{2} \quad 64.39 = 96.59$$

Para el cuarto paso procedemos de la misma manera y obtenemos $h3 = 2d3$

$$D = \sqrt{9\,d3} = 3d3$$

$$d3 = \frac{D}{3} = \frac{170}{3} = 56.6$$

$$h3 = 2d3 = 2 \times 56.6 = 113.3$$

y de ésta forma podemos dar el último paso de 55 mm Ø y 116 de altura - puesto que las diferencias son mínimas .

....#....

Cuando la lámina toma dureza entre paso y otro y se fractura, es conveniente recocerla para devolverle su ductibilidad .

Ejercicio :

Calcular de acuerdo al planeamiento anterior el desarrollo y de cuantos golpes podemos sacar la pieza que tiene 65 de Ø y 108 de altura .

Nota : Hacer este ejercicio en una hoja aparte) .

La forma que debemos dar a las operaciones de embutido, nos las muestra la figura 16 , ésta forma además de permitir un deslizamiento adecuado, nos permite un centrado en el troquel que realiza el paso siguiente como podemos observar en la figura 17 .

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DISEÑO DE HERRAMENTAL

MAQUINADO

ING. CARLOS PROAL MIRANDA.

JUNIO ,1978.

Palacio de Minería Calle de Tacuba 5, primer piso. México 1, D. F.

TALADROS - TALADRADORAS.

Son máquinas que tienen el fín primordial de realizar agujeros ó barrenos. Las herramientas que utilizan son las brocas dotadas de movimiento giratorio continuo y de movimiento rectilíneo de avance, siguiendo el -- eje de perforacion.

La figura 1 muestra algunos otros tipos de operaciones que pueden realizarse en un taladro.

CLASIFICACION.

a) Taladros portátiles los hay manuales, neumáticos ó electricos como su nombre lo indica se operan a mano y se utilizan principalmente en la construcción; Potencia hasta 3/4 H.P.

b) Taladros sensitivos. La rotación de la herramienta se hace por medio de un motor juego de poleas y banda y de un husillo porta broca ó mandril que sujeta a la herramienta. El movimiento de avance lo hace el operario. Normalmente vienen equipados en los husillos con conos Jacobs para montar broqueros ó con conos Morse interiores para montar directamente las herramientas. Potencias hasta 1.5 H.P.
Los hay de banco y de columna. Tienen velocidades de rotación ajustables por cambio de poleas.

c) Taladros con avance automático.
En este caso la rotación y avance lo hace en forma mecánica, neumática ó hidráulica el taladro mismo.
Los hay de columna y de banco.
La velocidad de rotación y avance son variables normalmente por cambios de engranes.

d) Taladro radial.
Consta de una base a la cual se fija una columna y a esta un brazo giratorio sobre el cual se desliza transversalmente la cabeza taladradora. Sobre la base se monta un cubo de apoyo al cual se sujetan ya sea morsas ó la pieza misma.

Prensas.
El desplazamiento vertical del brazo porta cabeza taladradora puede ser manual ó mecánico.

La cabeza taladradora cuenta con velocidades de rotación y avance variables.

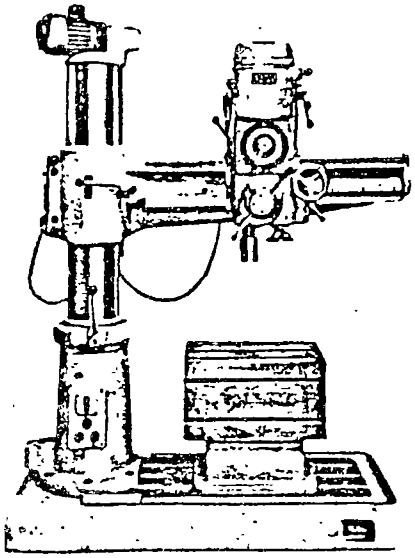
e) Taladradora de brazos articulados.
El cabezal puede alcanzar cualquier punto de la mesa con solo empujarlo en la dirección deseada cuando se encuentra en la posición deseada se bloquea en posición por medio de un gatillo. Su velocidad es variable pero sus avances son sensitivos.

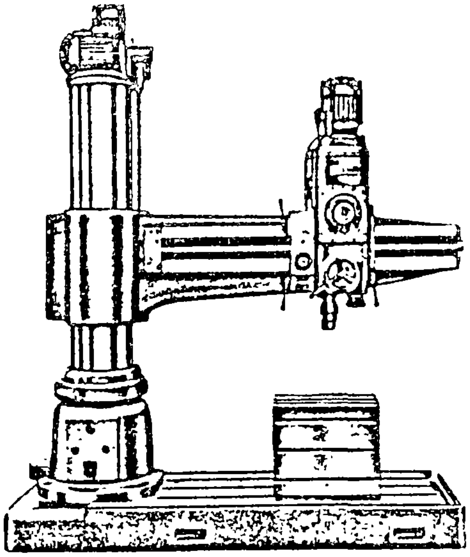
f) Taladros de producción.

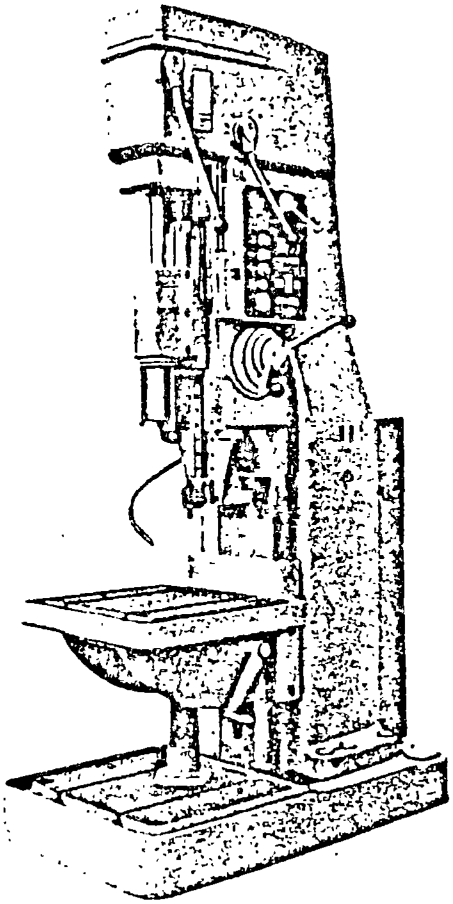
Ver sección de Máquinas de producción.
Sección II - 2

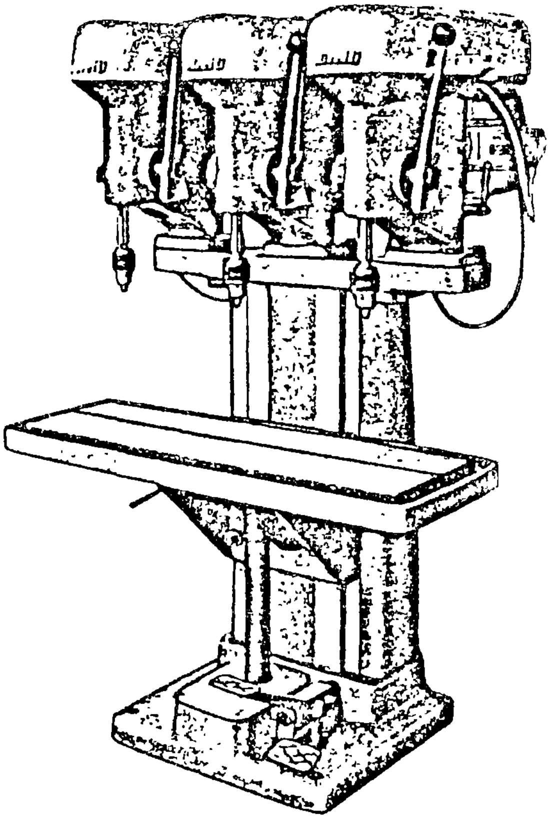
Herramientas para taladrar.

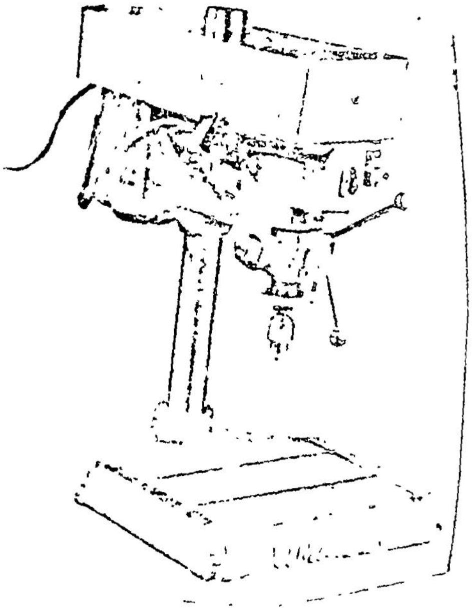
Ver Sección II - 5 Herramientas de corte.

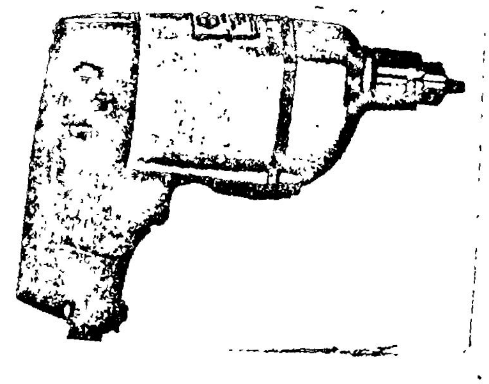


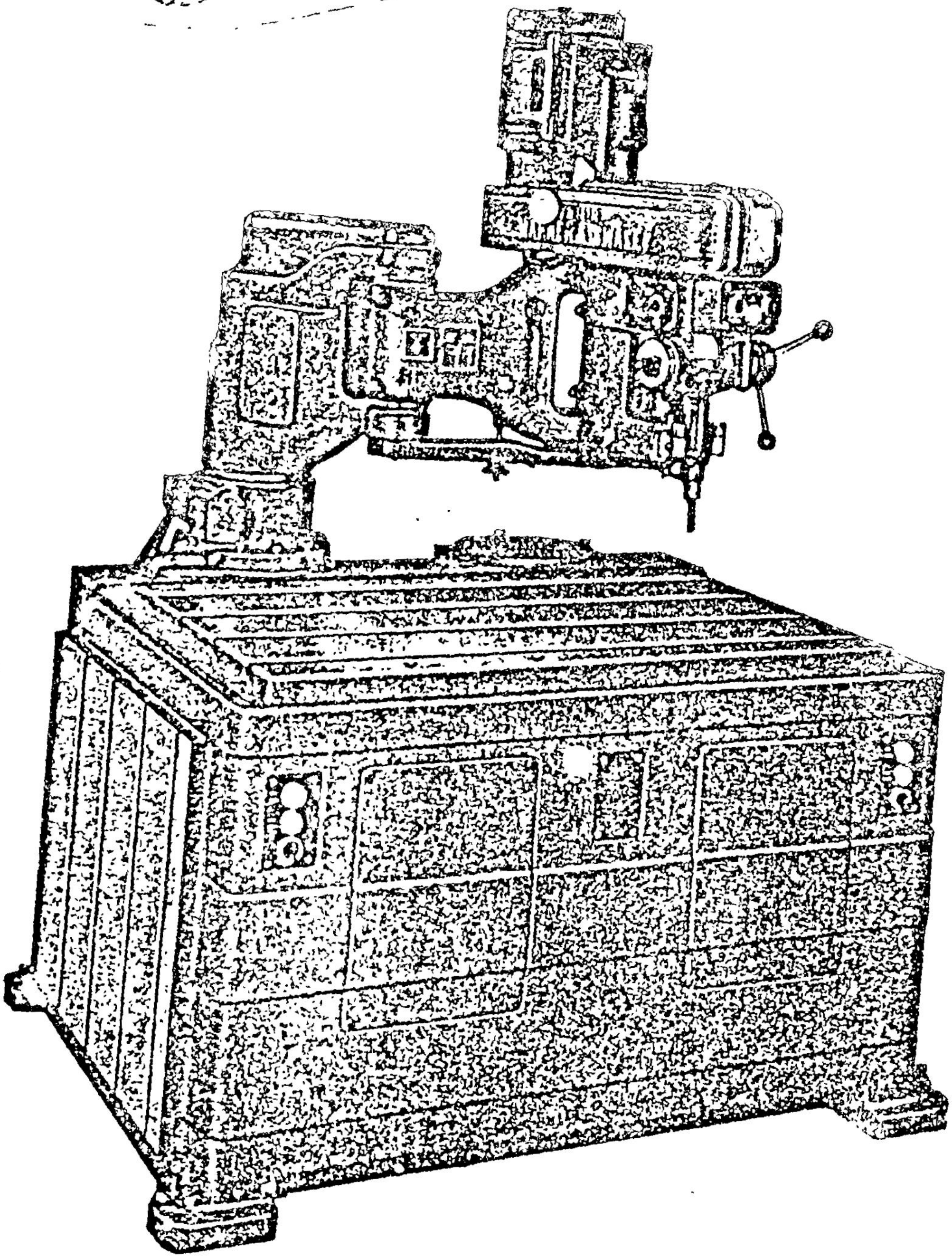


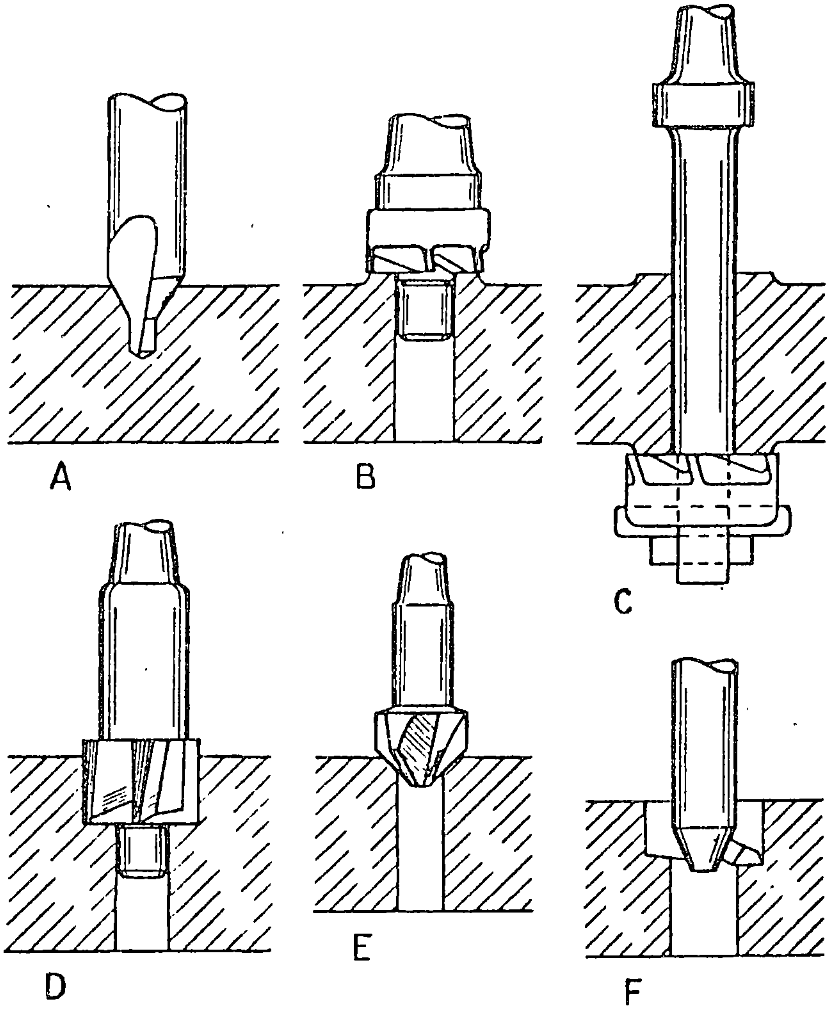












A) Localización de un barreno por medio de una broca de centros. No sé requiere entonces de un centro de localización.de barrenado que normalmente se hace con un punzon y martillo.

B) Avellanado superior

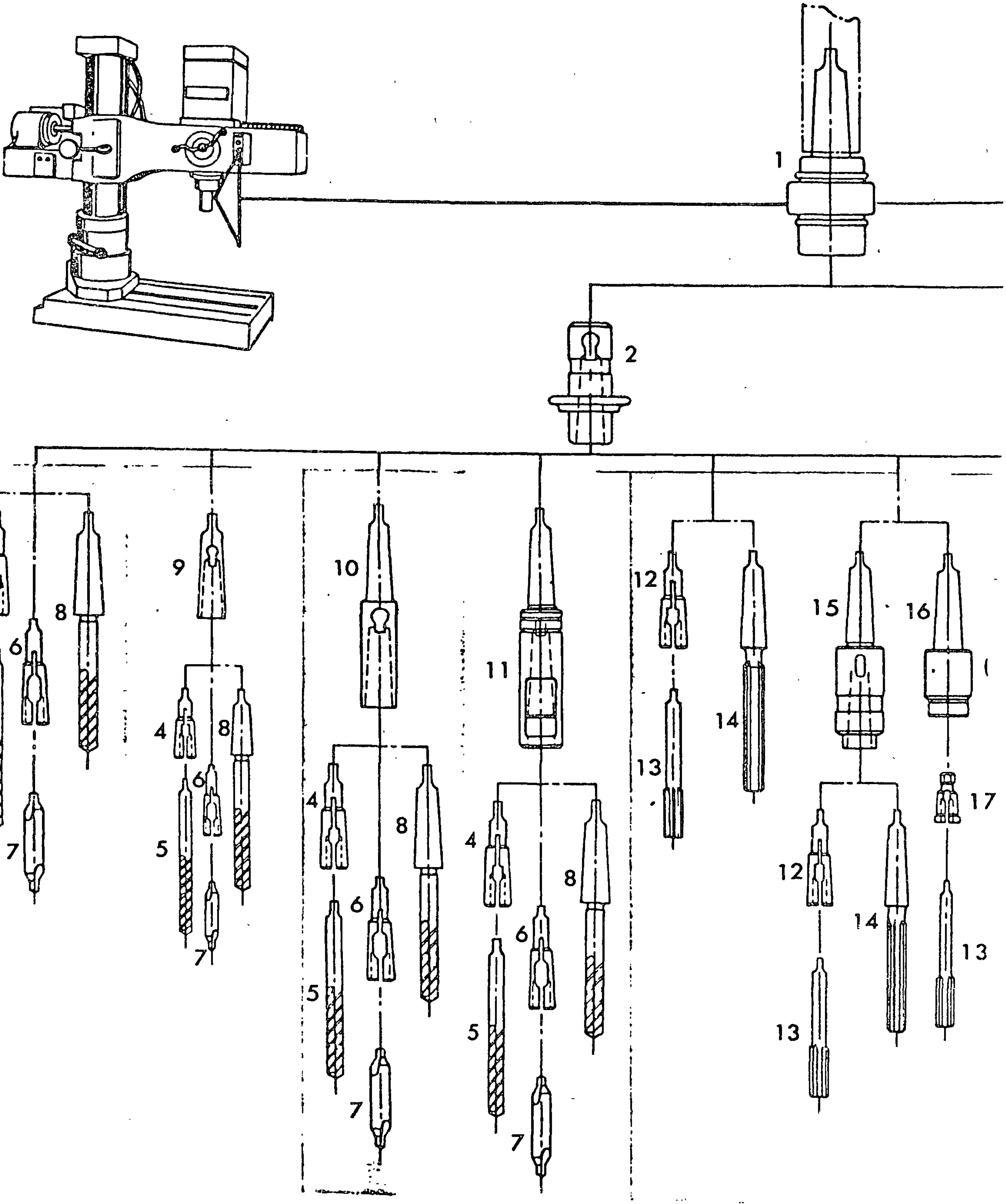
C) Avellanado inferior

D) Avellanado para ocultar la cabeza d un tornillo.

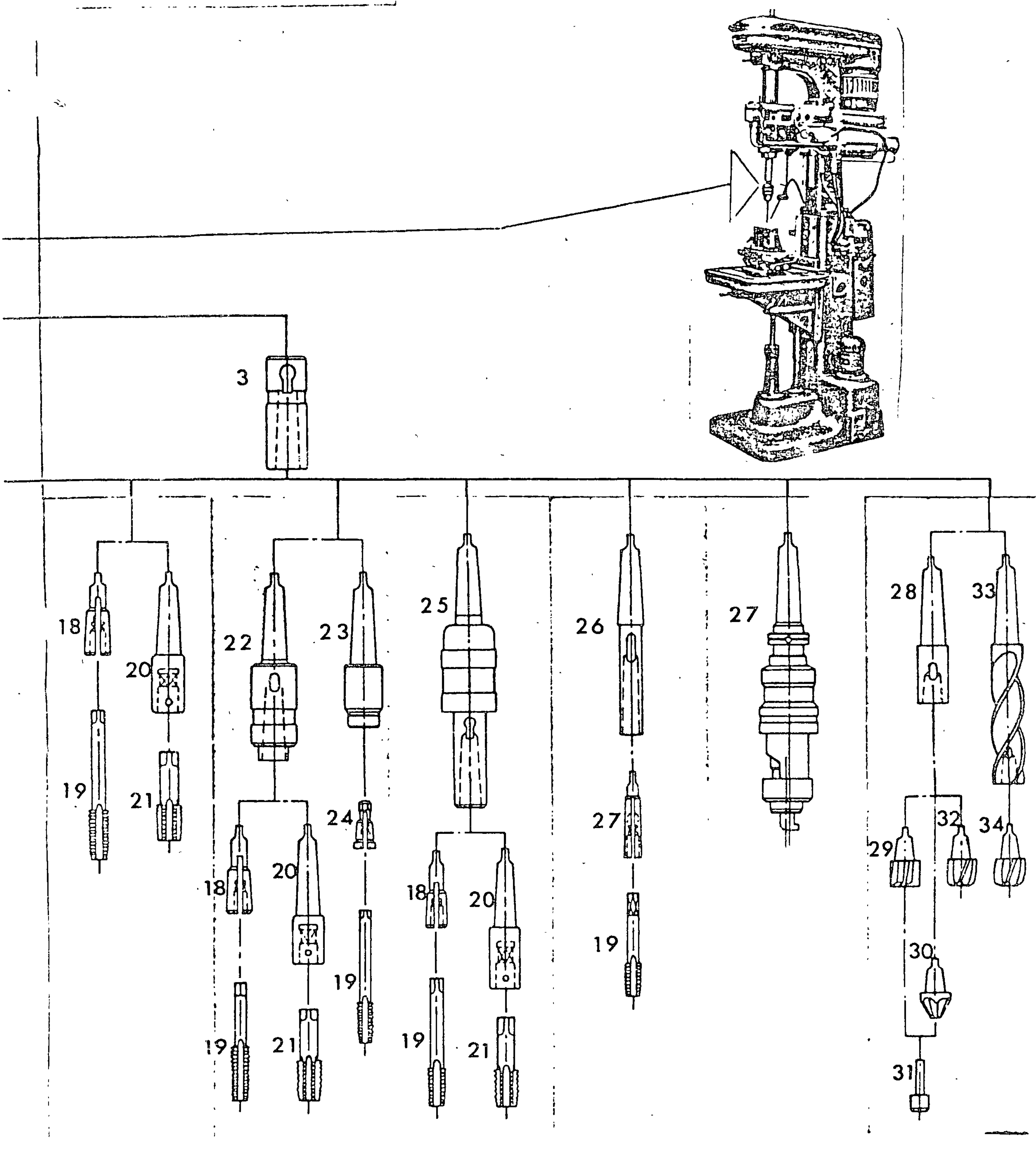
E) Achaflanado.

F) Avellanado con barra y buril.

HERRAMENTAL



PARA TALADROS



1.- Mandril de cambio rápido.
2.- Boquilla de cambio rápido con rondana protectora contra deslizamiento.
3.- Boquilla de cambio rápido.
4.- Boquilla ranurada para broca. (Para sujeción de herramientas con zanco cilindrico y lengueta de arrastre, llamadas serie automotriz)
5.- Broca.
6.- Boquilla ranurada para broca de centro.
7.- Broca de centros.
8.- Broca con zanco cónico gavilanes helicoidales, hélice derecha, corte a la derecha.
9.- Boquilla de reducción cono Morse "X" a cono Morse "Y"
10.- Boquilla de extensión cono Morse exterior "X" a cono Morse interior "Y".
11.- Tope positivo para broca.
12.- Boquilla ranurada para rima.
13.- Rima zanco recto con lengueta de arrastre, gavilanes rectos cortos, corte a la derecha.
14.- Rima zanco conico cono Morse "X" gavilanes rectos largos, corte a la derecha.
15.- Soporte flotante para rima.
16.- Soporte flotante para rima con boquilla de cambio rápido.
17.- Boquilla ranurada de cambio rápido para rima.
18.- Boquilla ranurada para machuelo.
19.- Machuelo zanco recto 4 gavilanes rectos corte a la derecha.
20.- Mandril de sujeción para machuelo.
21.- Machuelo para tuberia.
22.- Soporte flotante para machuelo.
23.- Soporte flotante para machuelo con boquilla de cambio rápido.
24.- Boquilla de cambio rápido ranurada para machuelo.
25.- Protector de torsión para machuelo.
26.- Extensión para machuelo
27.- Ranurador automático.
28.- Mandril porta avellanador zanco cono Morse X, cono Stub Morse "Y"
29.- Avellanador con piloto intercambiable zanco stub Morse "X" gavilanes helicoidales helice derecha corte a la derecha.
30.- Avellanador cónico con piloto intercambiable zanco stub Morse "Y" gavilanes rectos corte a la derecha.

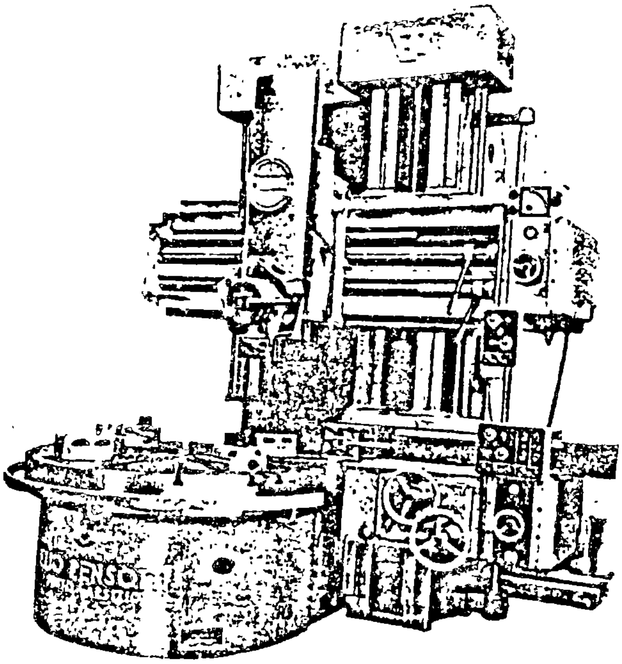
31.- Piloto para avellanador

32.- Avellanador sin piloto corte al centro zanco stub Morse "Y" gavilanes helicoidales hélice derecha corte a la derecha.

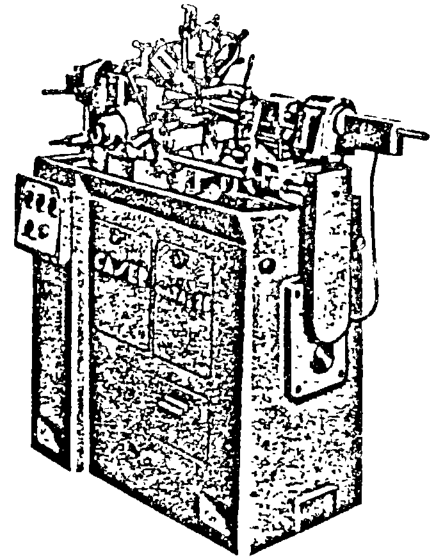
33.- Zanco intercambiable para broca de corazón, zanco cono Mórse "X" gavilanes helicoidales hélice derecha corte a la derecha con cono stub Morse Y.

34.- Punta intercambiable de broca de corazon zanco stub Morse -- "X" gavilanes helicoidales hélice derecha corte a la derecha.

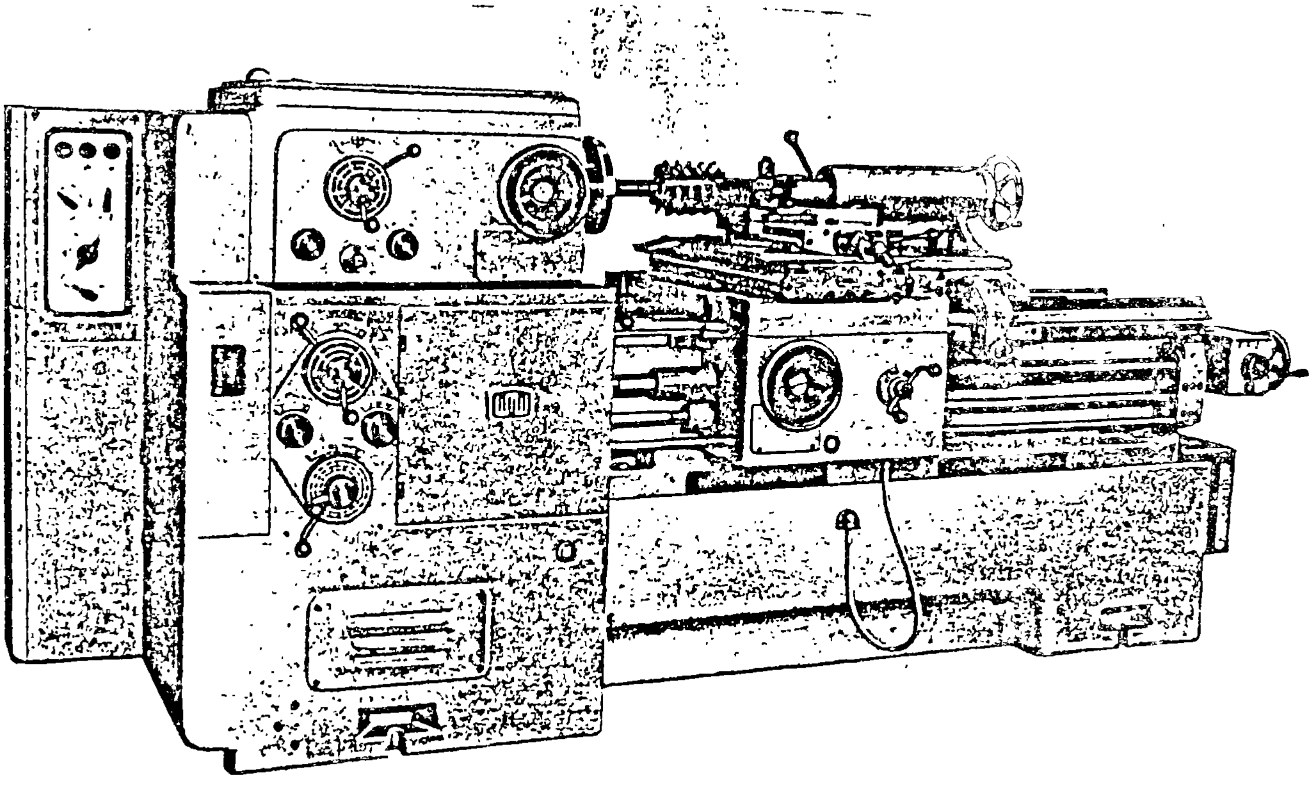
Ver tolerancia de construcción para estas herramientas en la sección II - 7 Información adicional y sección II - 5 Herramientas de corte.

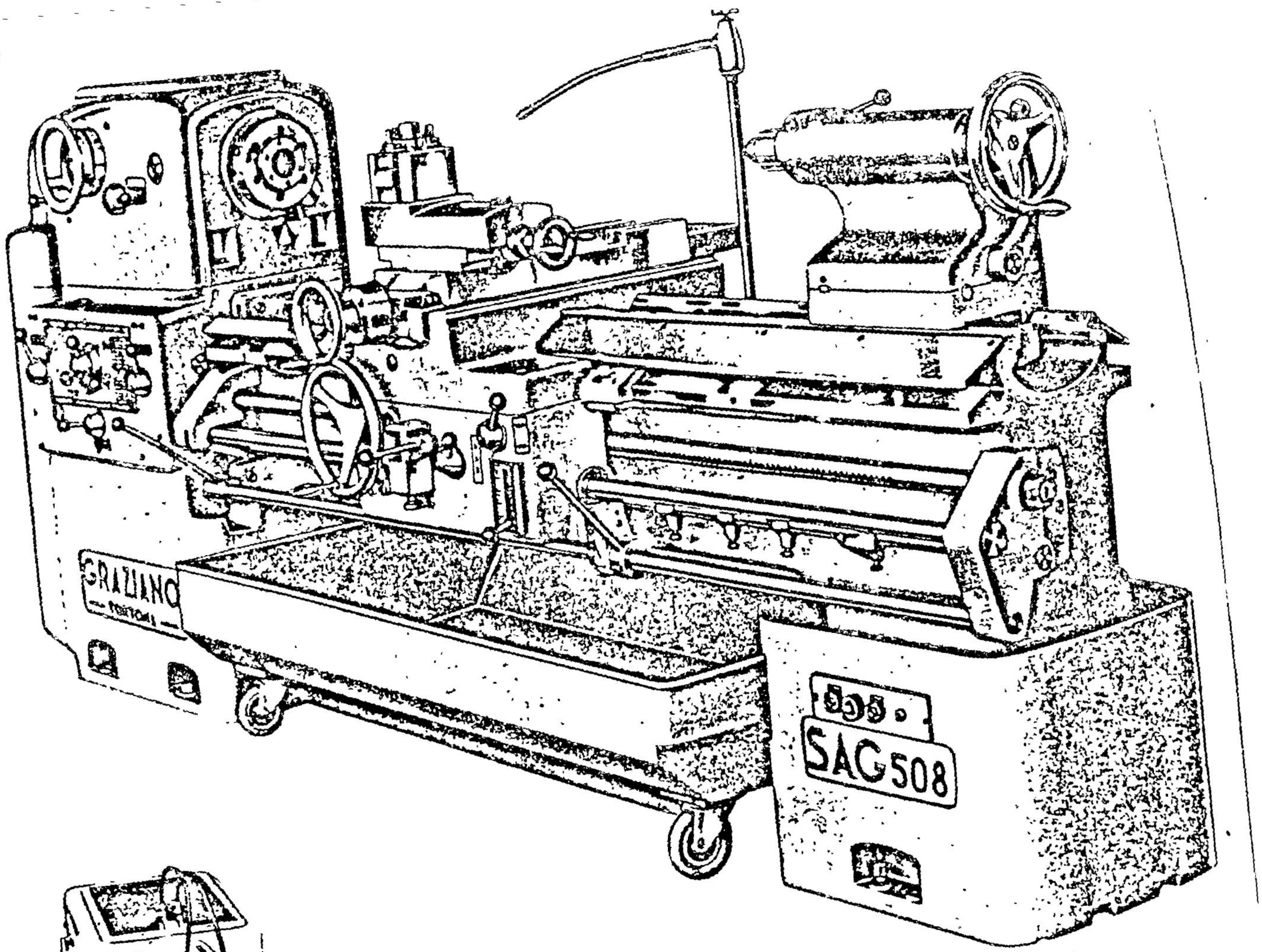


TORNO VERTICAL



TORNO AUTOMATICO DE UN HUSILLO «CASER» Mod. TA 26. Paso de la barra 26 mm - Largo máximo torneable 70 mm - Producción horaria 27-2020 piezas - Está dotado de un vasto surtido de accesorios especiales, que usados oportunamente, permiten la ejecución de cualquier tipo de piezas.

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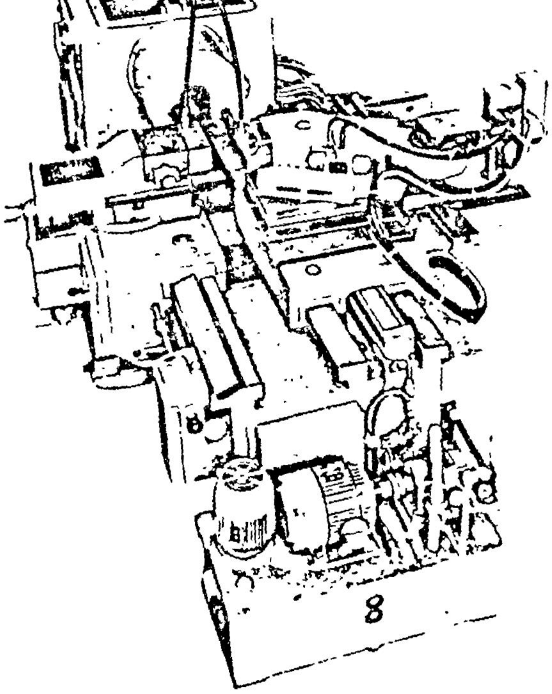
TORTONA
SAG 508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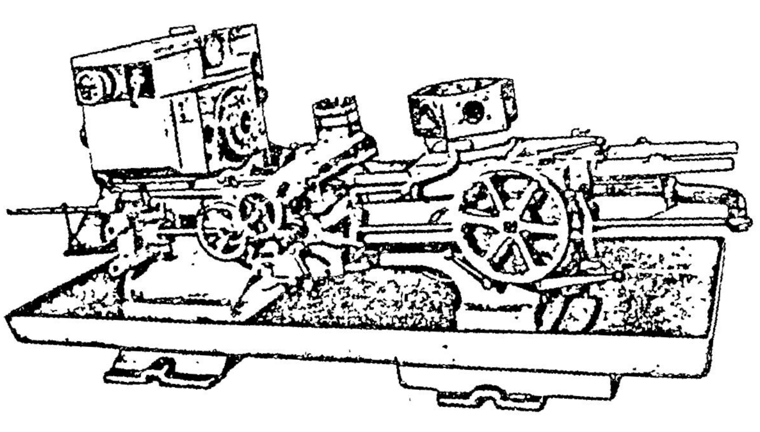
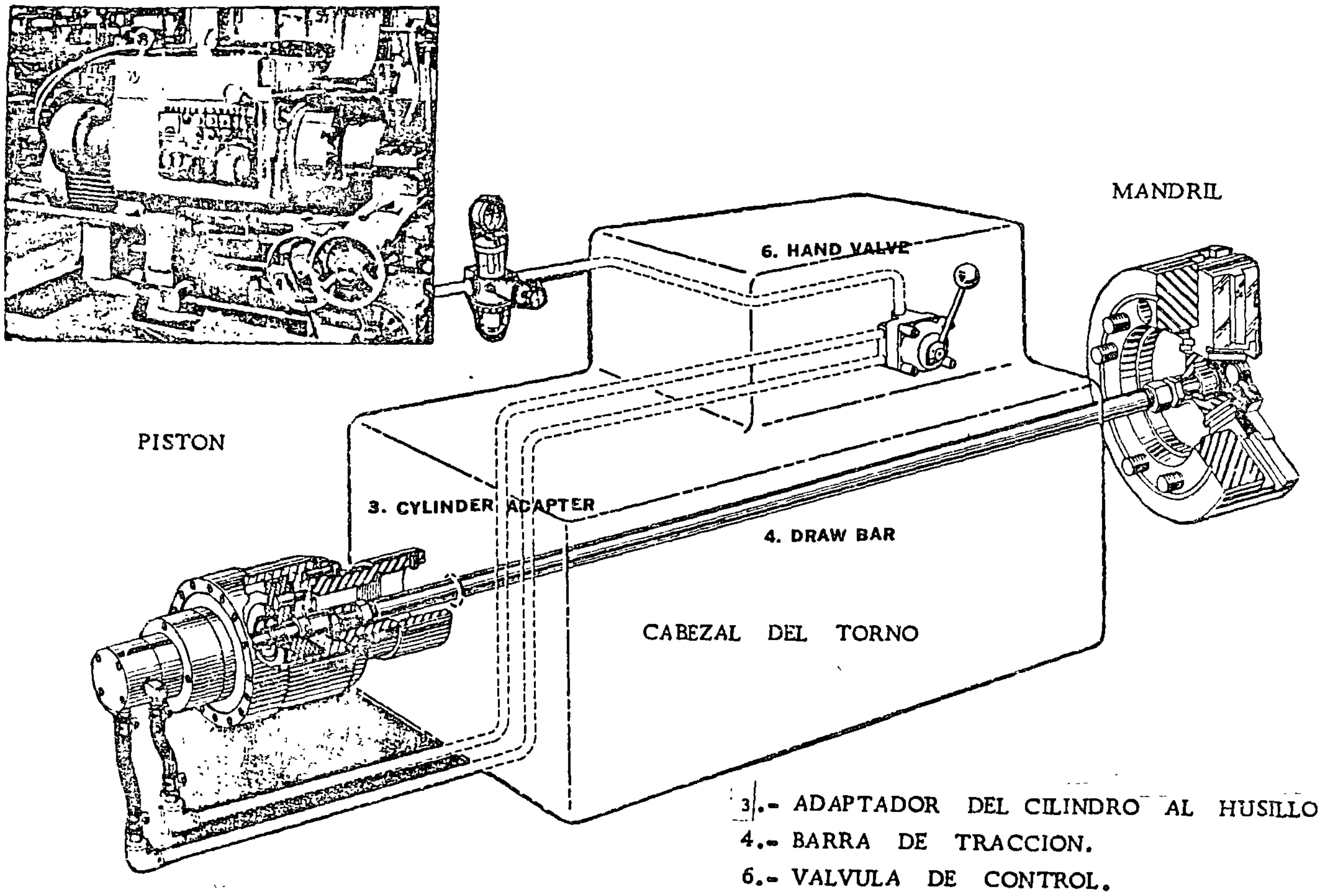
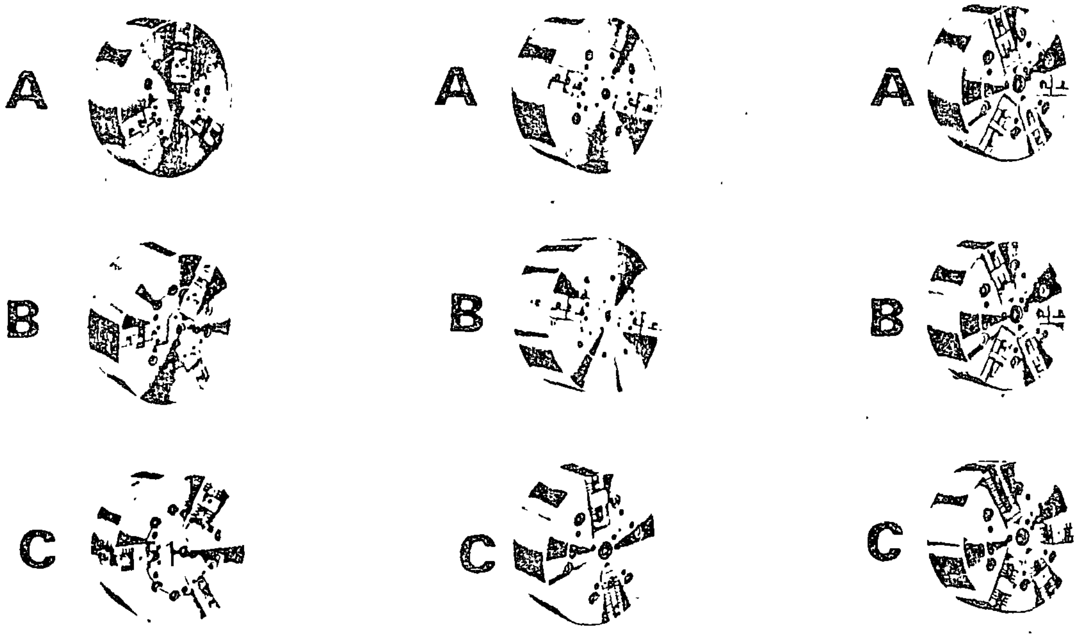




3.- ADAPTADOR DEL CILINDRO AL HUSILLO.
4.- BARRA DE TRACCION.
6.- VALVULA DE CONTROL.



SISTEMA DE PLATO DE SUJECION NEUMATICO O HIDRAULICO PARA TORNO.

Permite cargar y descargar las piezas con gran rapidez.

Su apertura ó cierre se hace por medio del pistón que acciona la barra de tracción y esta al mandril.

Se requiere de una fuente de aire comprimido ó de fuerza hidráulica para accionar el pistón.

La válvula direccional permite el paso del fluido en un sentido y otro para abrir y cerrar el mandril.

Existen varios modelos de platos de sujeción que a continuación se describen.

A) Plato de sujeción de tres mordazas autocentrantes con 3 mordazas mestras, cuerpo de acero templado guias rectificadas.

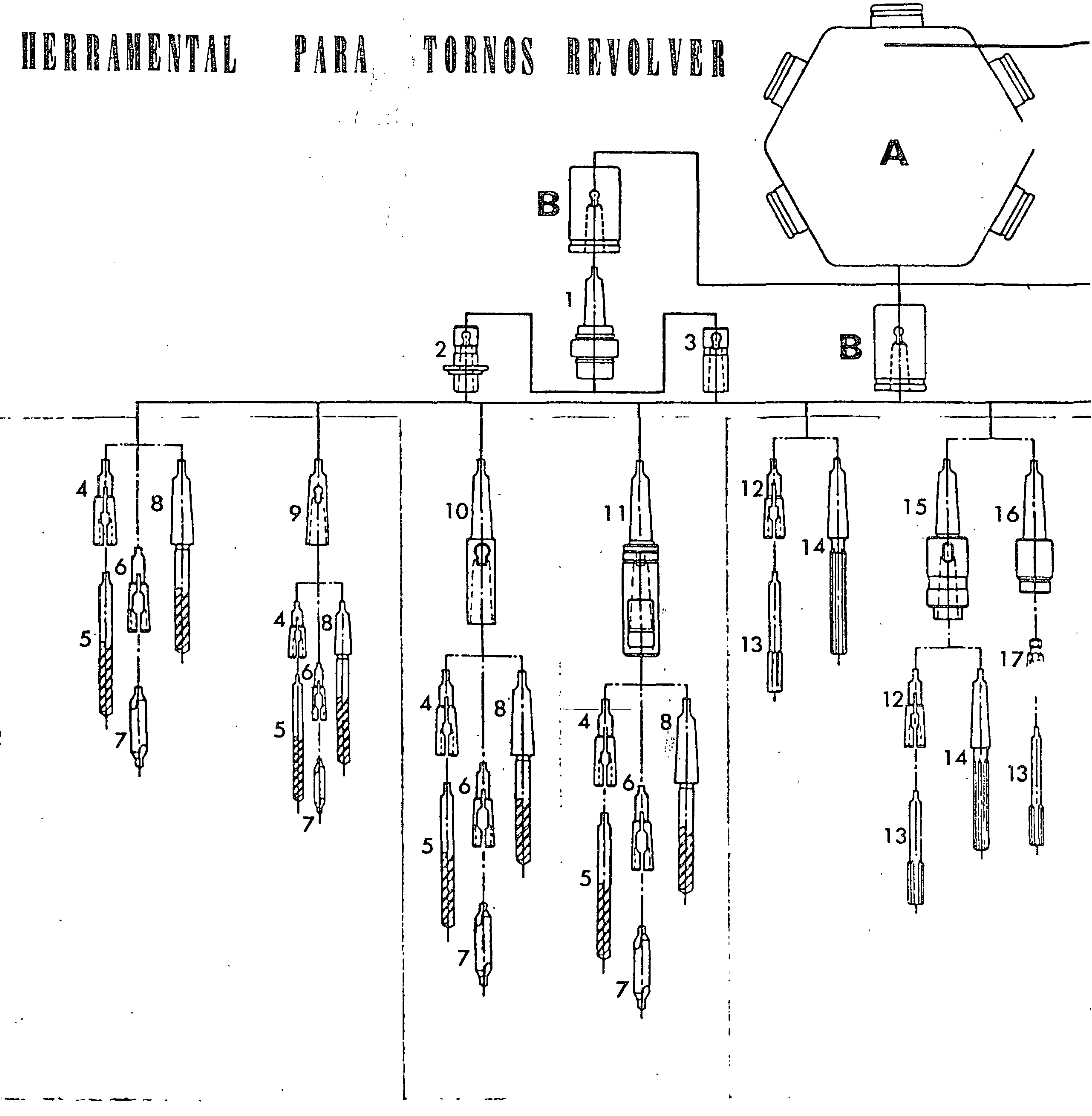
B) Plato de sujeción de tres mordazas autocentrantes ajustables con 3 mordazas maestras, cuerpo de acero templado con guías rectificadas (Permite compensar deformaciones de la pieza al compensar la deformación desplazando alguna ó varias de las mordazas y luego autocentrado en forma regular).

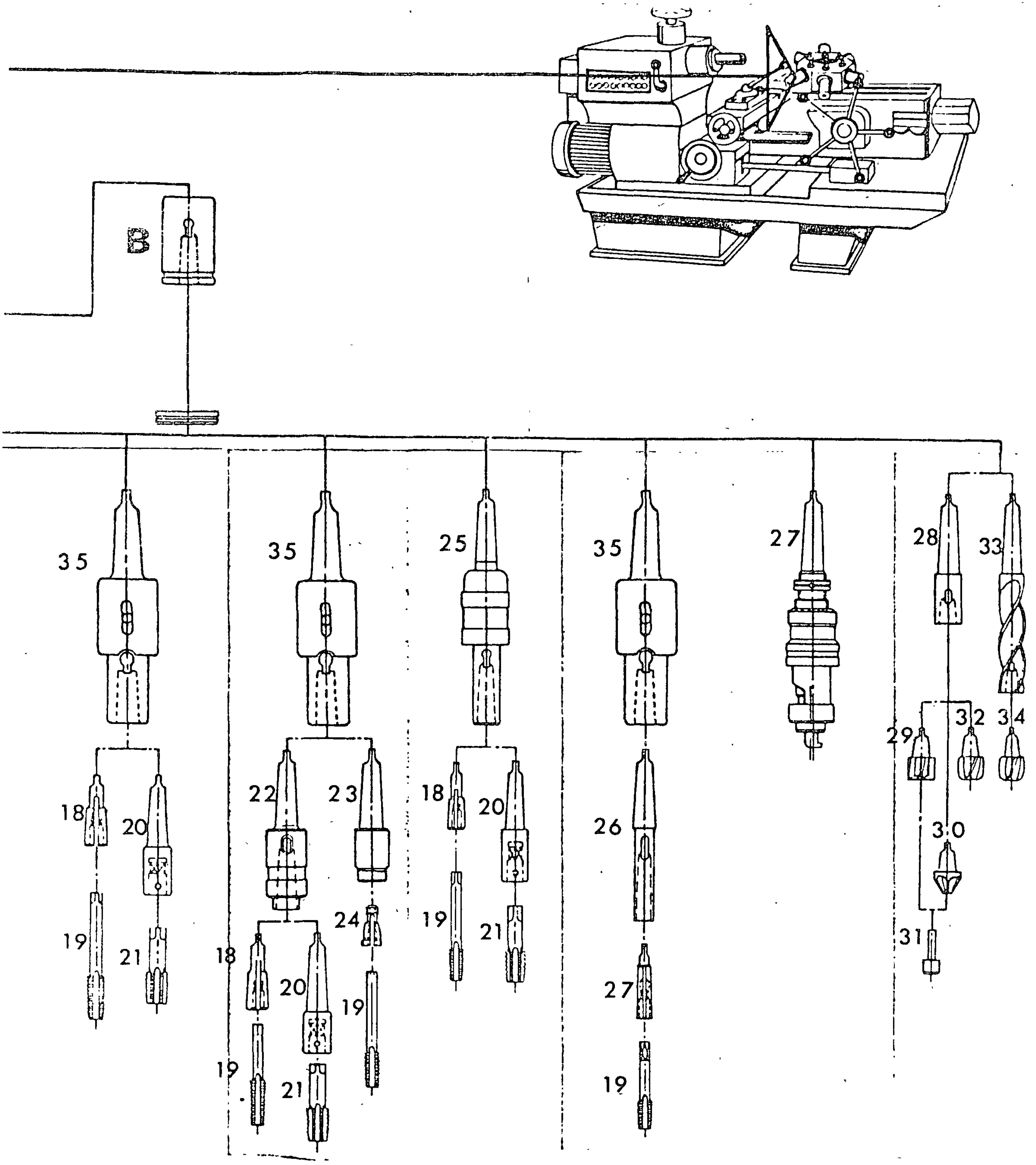
Los modelos A y B usan mordazas maestras con lengueta y dos tornillos de sujeción Estandar Americano (

C) Plato de sujeción de tres mordazas autocentrantes con 3 mordazas maestras del tipo cuña y ranuras (Estandar Americano)

Los modelos D, E, F, G, H, I, incorporan las mismas caracteristicas de los A, B, y C, pero en 2 y 2 y 3 Mordazas.

HERRAMENTAL PARA TORNOS REVOLVER

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A) TORRETA DEL TORNO REVOLVER.

B) BOQUILLA CILINDRICA PARA TORNO REVOLVER.

1.- Mandril de cambio rápido.

2.- Boquilla de cambio rápido con protector contra deslizamiento.

3.- Boquilla de cambio rápido.

4.- Boquilla ranurada para broca. (Para sujeción de herramientas con zanco cilindrico y lengueta de arrastre, llamadas serie automotriz).

5.- Broca.

6.- Boquilla ranurada para broca de centro.

7.- Broca de centros.

8.- Broca con zanco cónico gavilanes helicoidales, hélice derecha, corte a la derecha.

9.- Boquilla de reducción cono Morse "X" a cono Morse "Y"

10.- Boquilla de extensión cono Morse exterior "X" a cono Morse interior "Y"

11.- Tope positivo para broca.

12.0 Boquilla ranurada para rima.

13.- Rima zanco recto con lengueta de arrastre, gavilanes rectos cortos, corte a la derecha.

14.- Rima zanco cónico cono Morse "X" gavilanes rectos largos, corte a la derecha.

15.- Soporte flotante para rima.

16.- Soporte flotante para rima con boquilla de cambio rápido.

17.- Boquilla ranurada de cambio rápido para rima.

18.- Boquilla ranurada para machuelo.

19.- Machuelo zanco recto 4 gavilanes rectos corte a la derecha.

20.- Mandril de sujeción para machuelo.

21.- Machuelo para tuberia.

22.- Soporte flotante para machuelo.

23.- Soporte flotante para machuelo con boquilla de cambio rápido.

24.- Boquilla de cambio rápido ranurada para machuelo.

25.- Protector de torsión para machuelo.

26.- Extensión para machuelo.

27.- Ranurador automático.

28.- Mandril porta avellanador zanco cono Morse X, cono Stub Morse "Y"

29.- Avellanador con piloto intercambiable zanco stub Morse "X" gavilanes helicoidales hélice derecha corte a la derecha.

30.- Avellanador cónico con piloto intercambiable zanco stub Morse "Y" gavilanes rectos corte a la derecha.

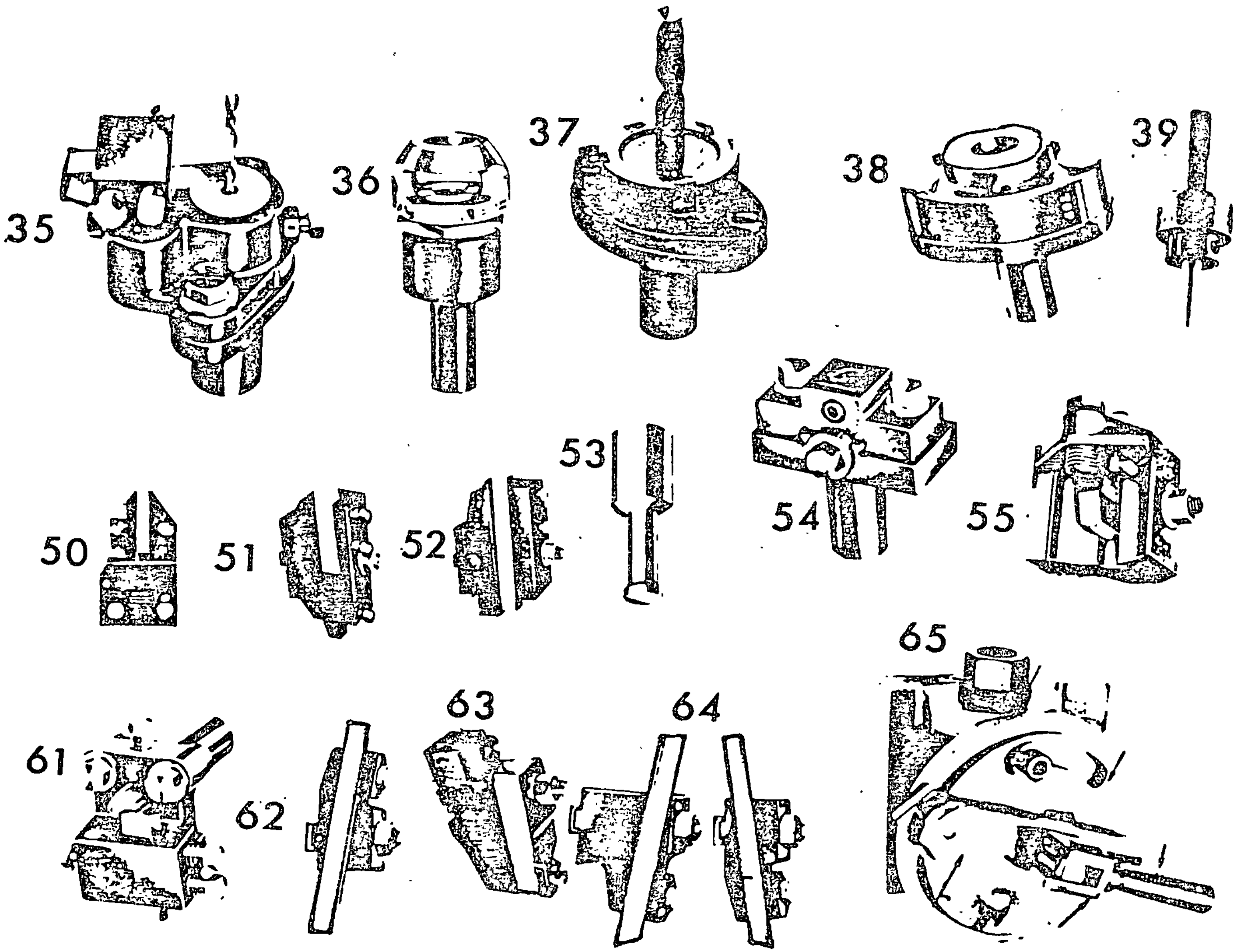
31.- Piloto para avellanador.

32.- Avellanador sin piloto corte al centro zanco stub Morse "Y" gavilanes helicoidales hélice derecha corte a la derecha.

33.- Zanco intercambiable para broca de corazón, zanco cono morse "X" gavilanes helicoidales hélice derecha corte a la derecha con cono stub Morse "Y"

34.- Punta intercambiable de broca de corazón zanco stub Morse "X" gavilanes helicoidales hélice derecha corte a la derecha.

35.- Mandril de compensación para machuelos.



HERRAMENTAL PARA TORNOS AUTOMATICOS

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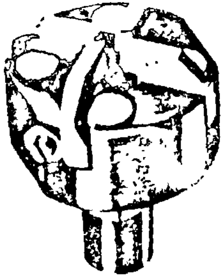

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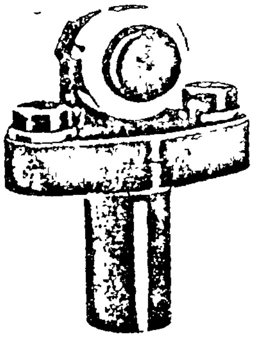

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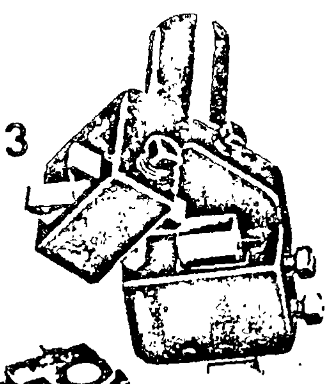

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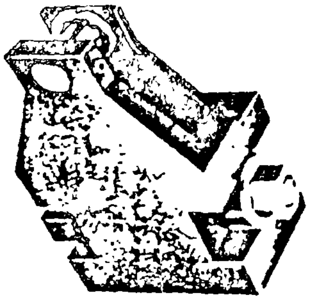

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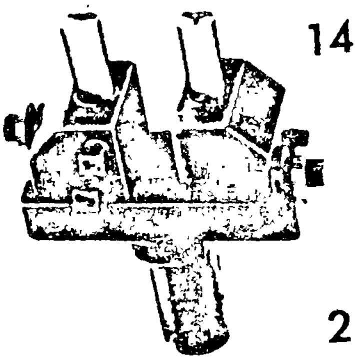

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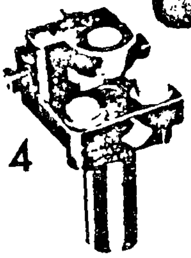

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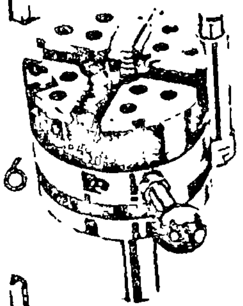

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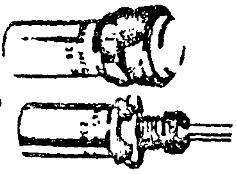

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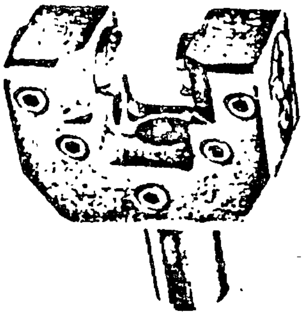

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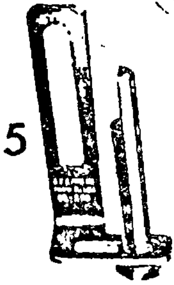

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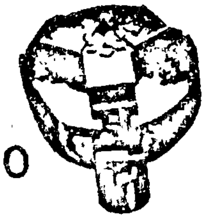

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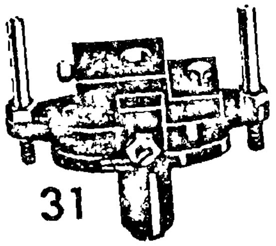

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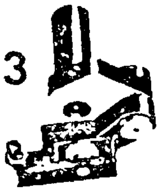

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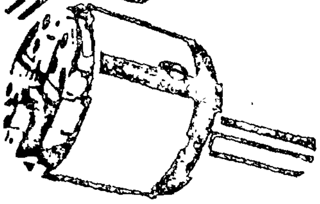

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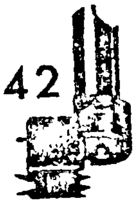

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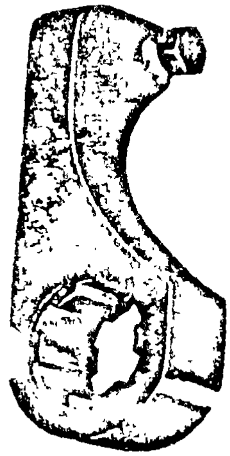

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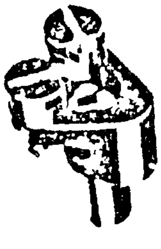

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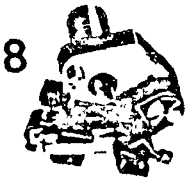

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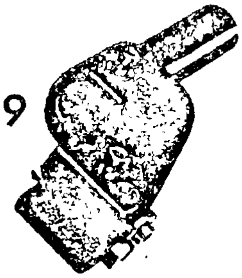

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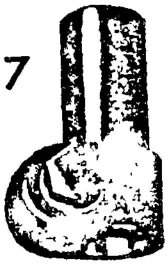

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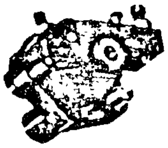

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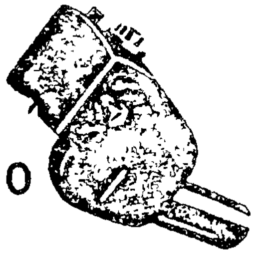

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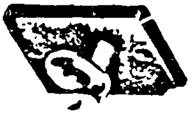

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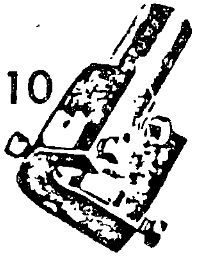

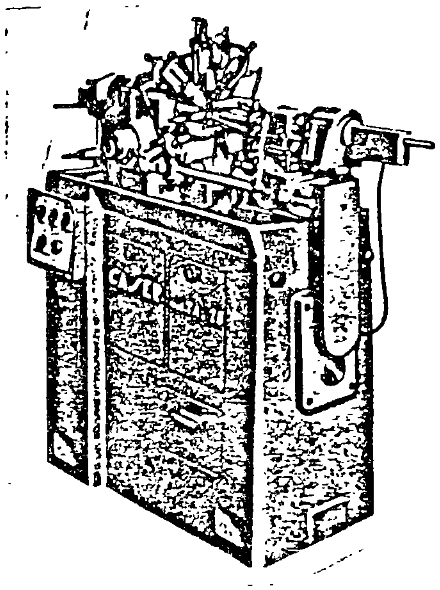

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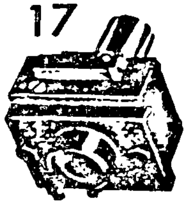

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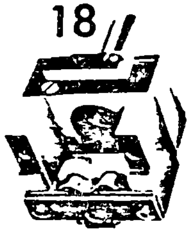

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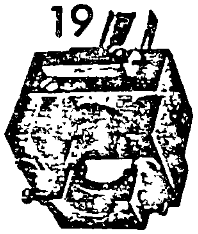

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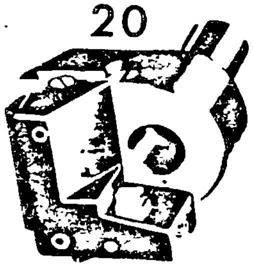

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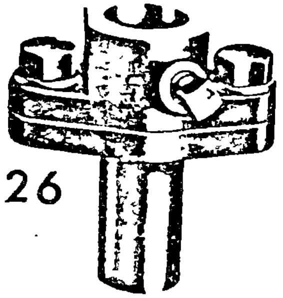

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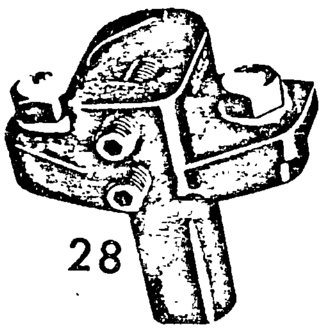

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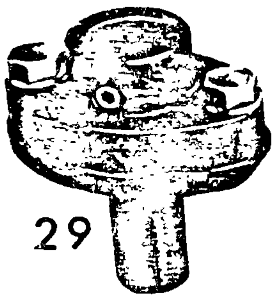
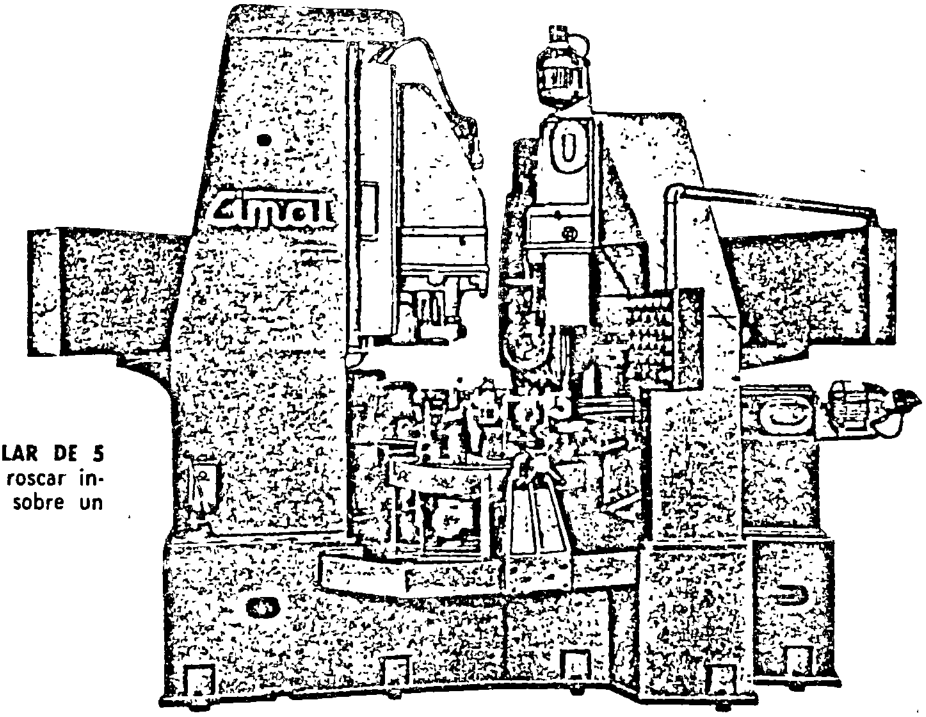


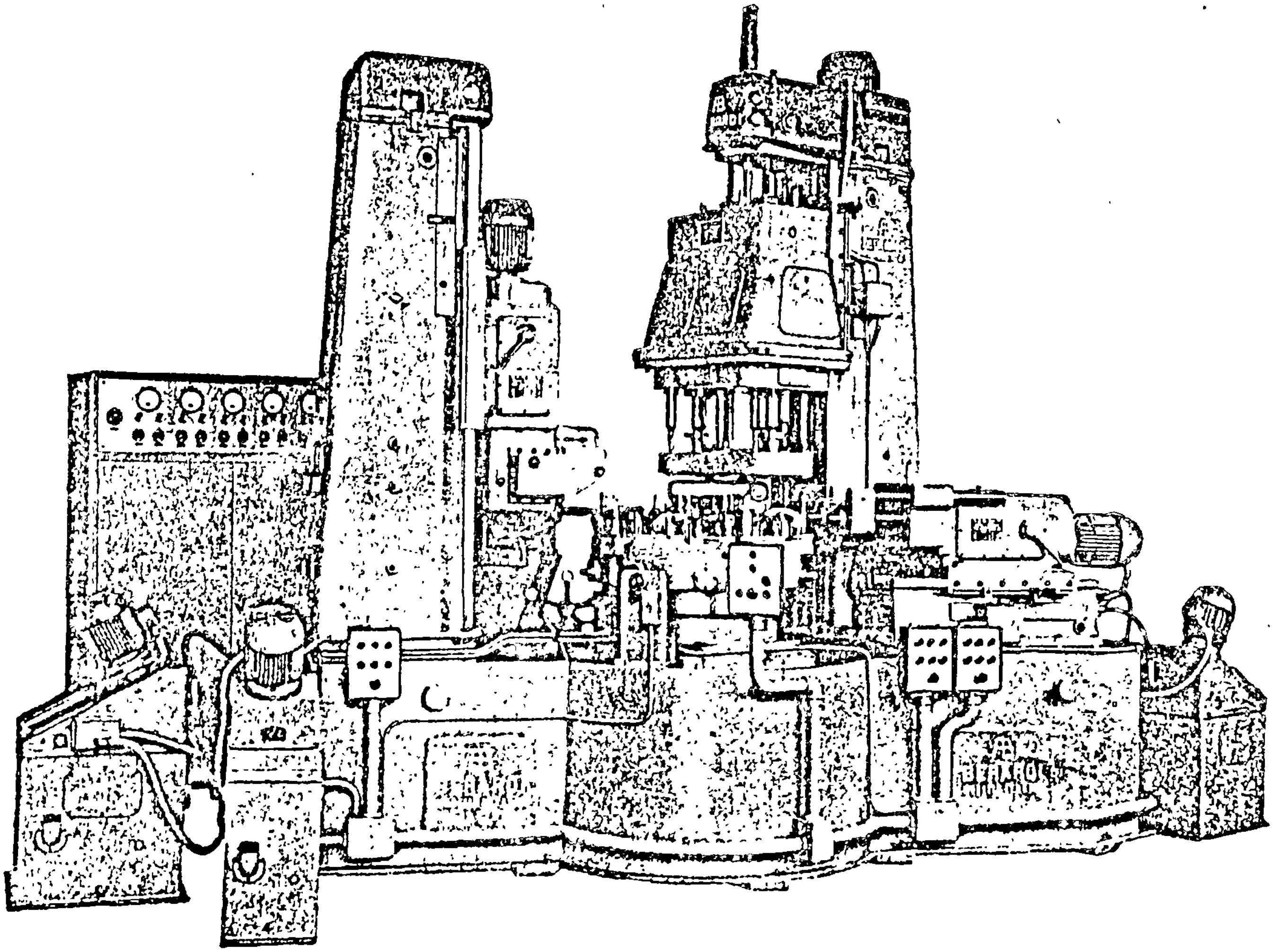
HERRAMIENTAS PARA TORNOS AUTOMATICOS.

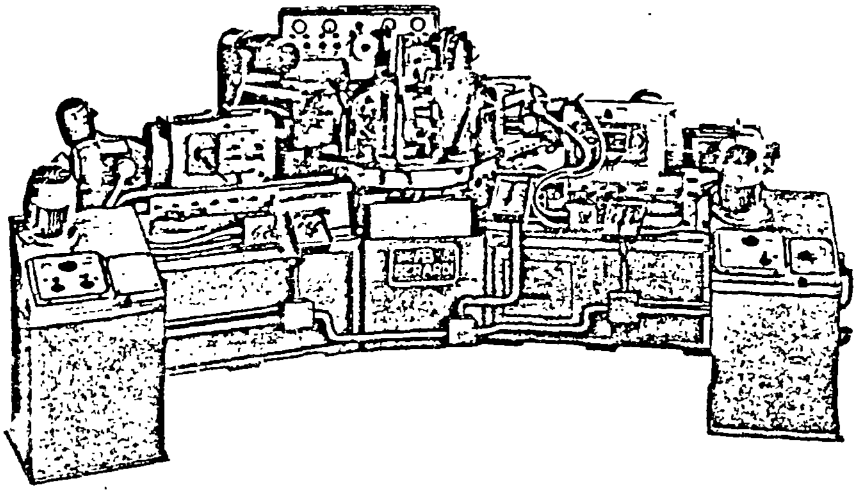
1.- Cabezal torneador ajustable.
2.- Portaburil redondo para puntear.
3.- Portaburil tipo caja
4.- Soporte para rolar
5.- Portaburil para ranurar
6.- Porta moletas
7.- Porta buril
8.- Soporte deslizante de cabezas intercambiables
9.- Portaburil doble balanceado.
10.- Porta buril tipo caja.
11.- Tope giratorio.
12.- Avellanador exterior.
13.- Trepanador
14.- Apoyo.
15.- Peines para cabezal roscador.
16.- Cabezal roscador.
17.- Portaburil para ranurar
18.- Porta moletas.
19.- Portaburil
20.- Portaburil deslizante para tornear cónico.
21.- Porta buril tipo caja con rodillos.
22.- Tope giratorio
23.- Tope giratorio
24.- Moleteador
25.- Tope de cierre para cabezal roscador.
26.- Soporte ajustable para broca, rima ó machuelo
27.- Soporte combinación para rimar y achaflanar.
28.- Soporte ajustable para broca.
29.- Soporte flotante para machuelo.
30.- Cabezal rolador
31.- Ranurador
32.- Leva para conos.
33.- Soporte basculante para conos.
34.- Cabezales roscadores
35.- Soporte para taladrar y achaflanar.
36.- Soporte "Acom" para roscar.
37.- Porta broca.
38.- Machueleador

39.- Soporte flotante.
40.- Rodaje
41.- Tope
42.- Apoyo
43.- Leva
44.- Moleteador
45.- Palanca.
46.- Apoyo con rodajas
47.- Leva.
48.- Soporte basculante
49.- Portaburil
50.- Porta cuchillas
51.- Porta cuchillas
52.- Porta cuchillas.
53.- Buril para ranurar
54.- Cabezal ajustable
55.- Soporte para cortador de forma
56.- Porta herramienta.
57.- Tope
58.- Apoyo
59.- Soporte basculante
60.- Porta buril
61.- Herramienta para centrar y achaflanar.
62.- Porta cuchilla.
63.- Porta cuchilla.
64.- Porta cuchilla.
65.- Aditamento para afilar peines.

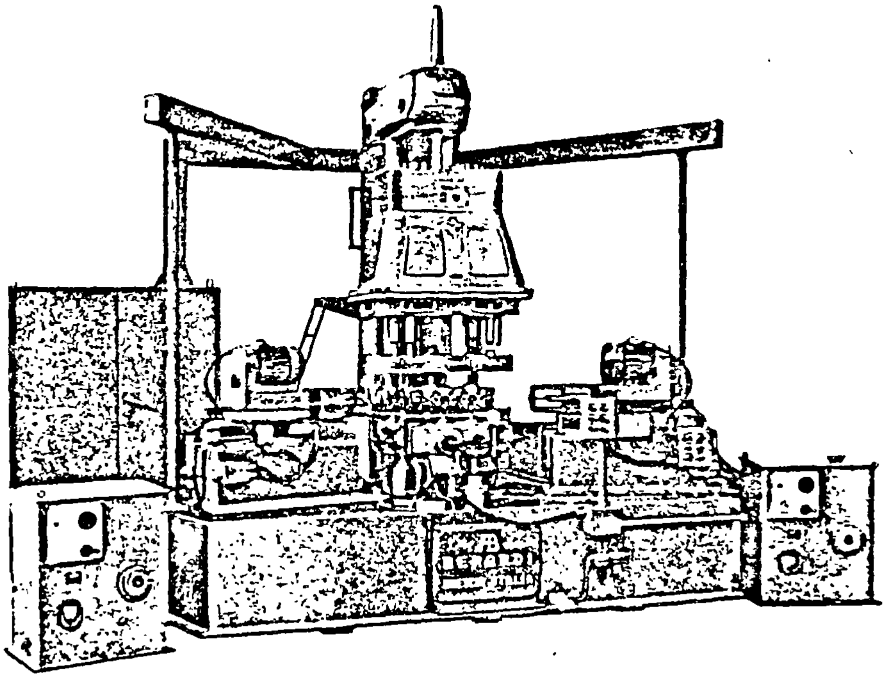


MAQUINA TRANSFER CIRCULAR DE 5 ESTACIONES para: taladrar, roscar interiores, fresar, mandrinar, sobre un cárter de aluminio.

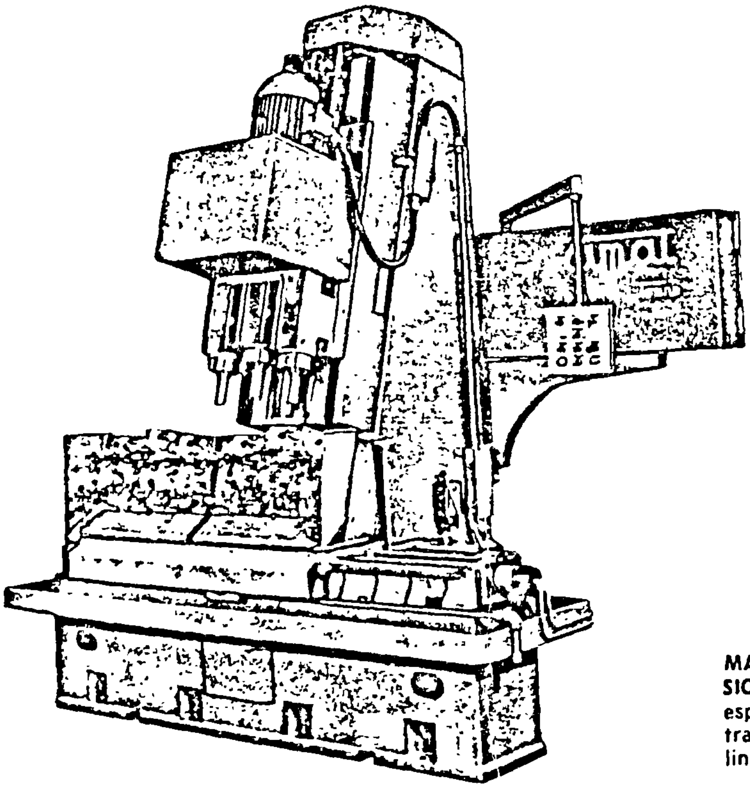




OPERADORA MULTIPLE ESPECIAL tipo O A II Z 4. Para trabajos combinados de mandrinado, planeado, taladrado y roscado para la ejecución del asiento del cilindro sobre base de aleación ligera para motovehículos. Porta-piezas montado sobre mesa con cinco posiciones, cuatro estaciones de trabajo y una de carga. **Producción:** 1 base cada 45 segundos.

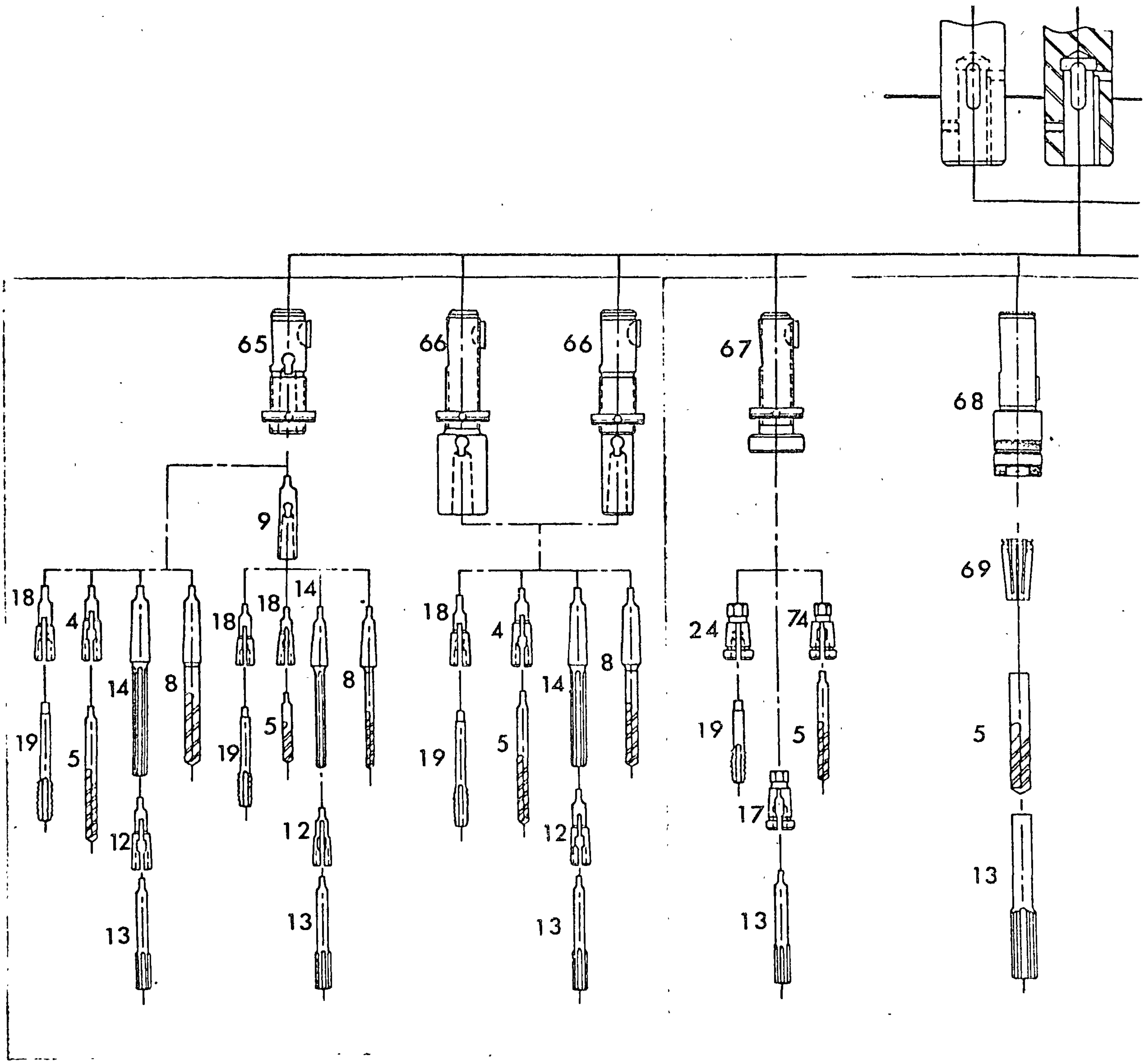


OPERADORA MULTIPLE ESPECIAL de tres cabezales tipo OVC III G 3 de ciclo automático completo con accionamiento oleodinámico para operaciones combinadas de taladrado - retaladrado - mandrinado - achaflanado, etc. de cuerpos de compresores frigoríficos. **Producción:** 150 piezas por hora.

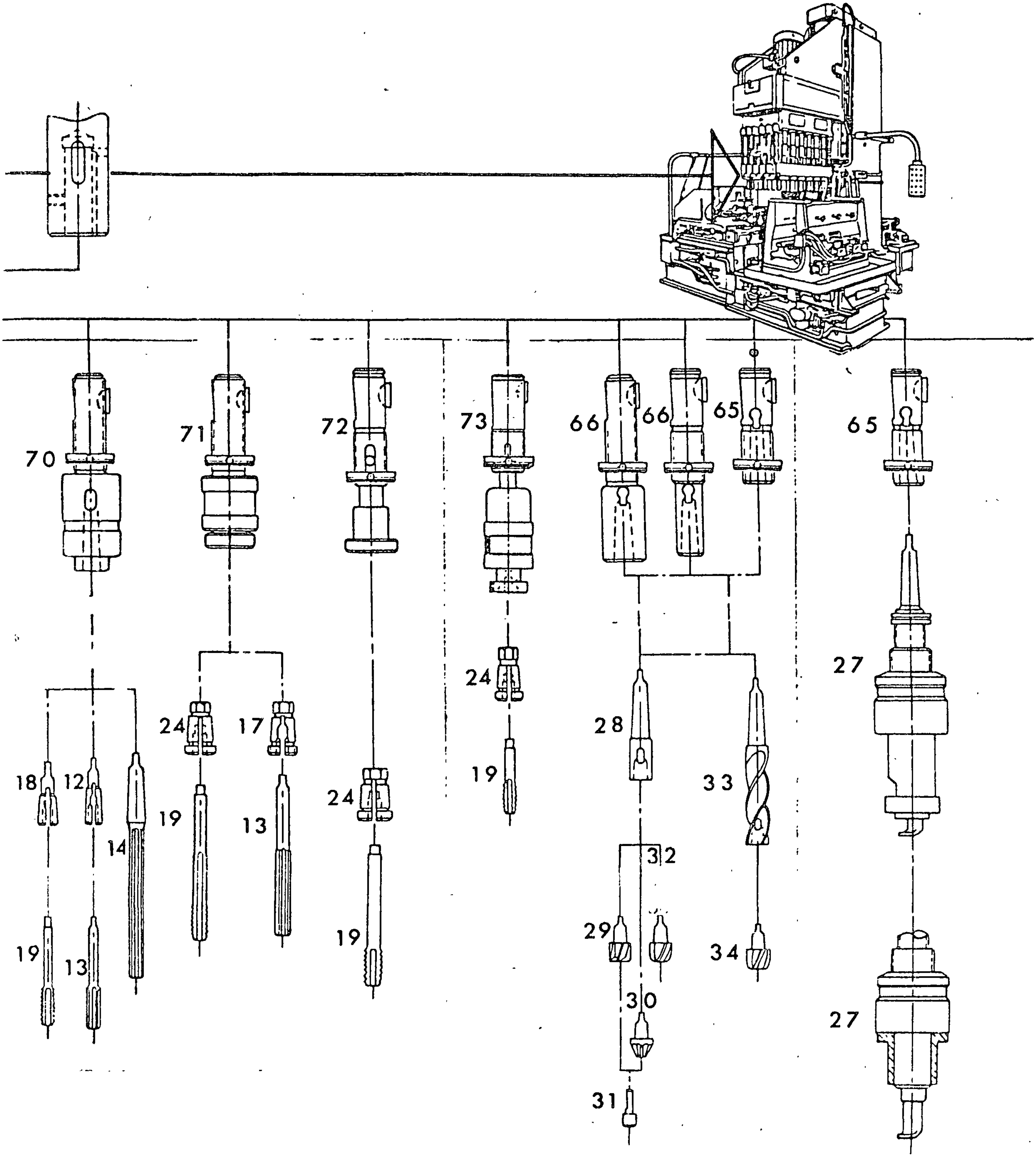


MANDRINADORA ESPECIAL DE 2 POSICIONES PARA CILINDROS. Máquinas especiales de posición fija - Máquinas transfer circulares - Máquinas transfer lineales.

HERRAMENTAL PARA MAQUINAS



DE HUSILLOS MULTIPLES



HERRAMENTAL PARA MAQUINAS DE HUSILLOS MULTIPLES.

65.- Boquilla ajustable con tuerca de ajuste.

66.- Boquilla ajustable de extensión con tuerca de ajuste.

67.- Boquilla ajustable con tuerca de ajuste con sistema de cambio rápido.

68.- Mandril porta brocas.

69.- Pinza de sujeción (Collet)

70 Mandril flotante con zanco ajustable con tuerca de ajuste.

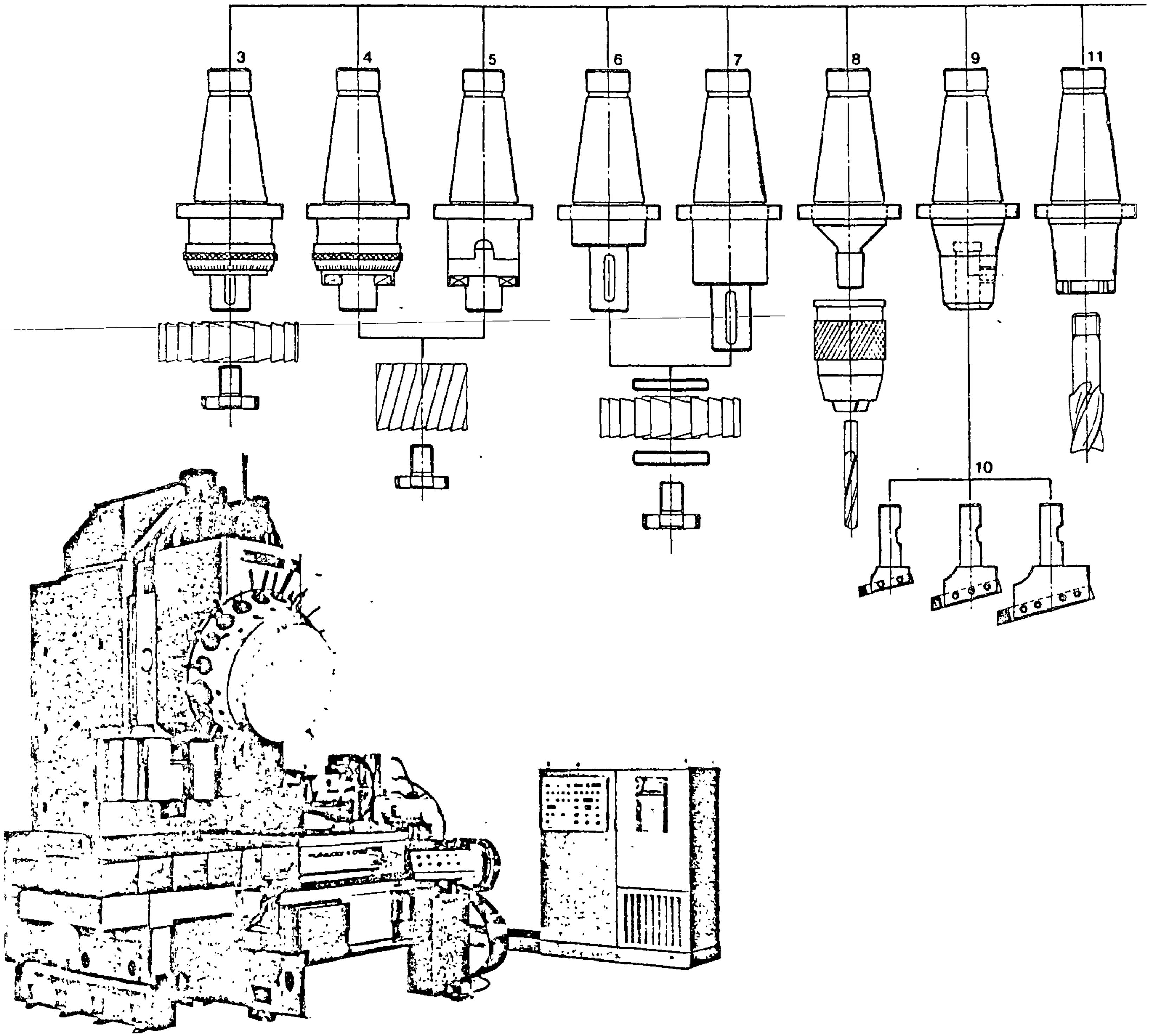
71.- Mandril de cambio rápido con zanco ajustable con tuerca de ajuste.

72.- Mandril de compensación con zanco ajustable y tuerca de ajuste.

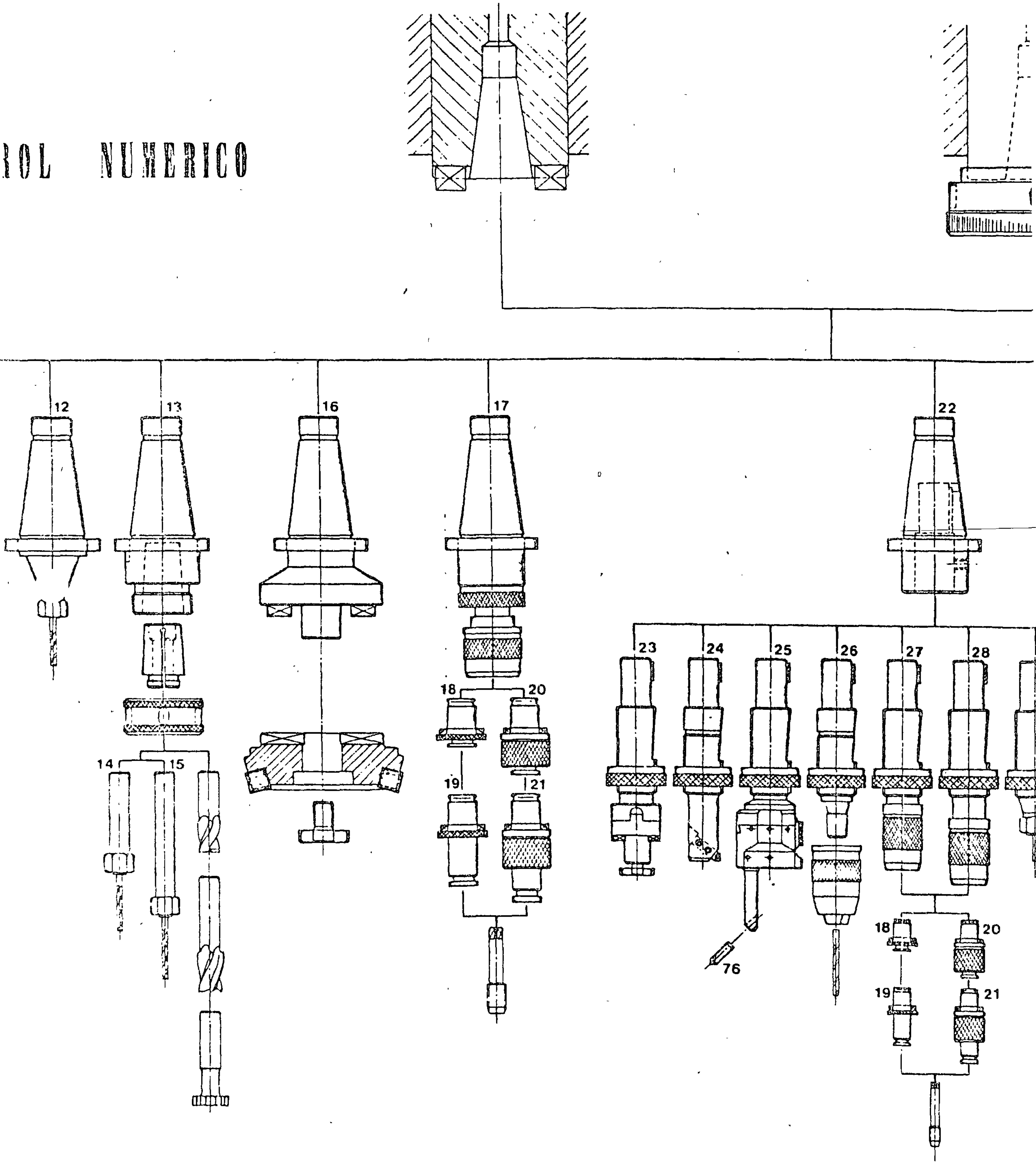
73.- Mandril de protección de torsión, compensación y cambio rápido con zanco ajustable y tuerca de ajuste.

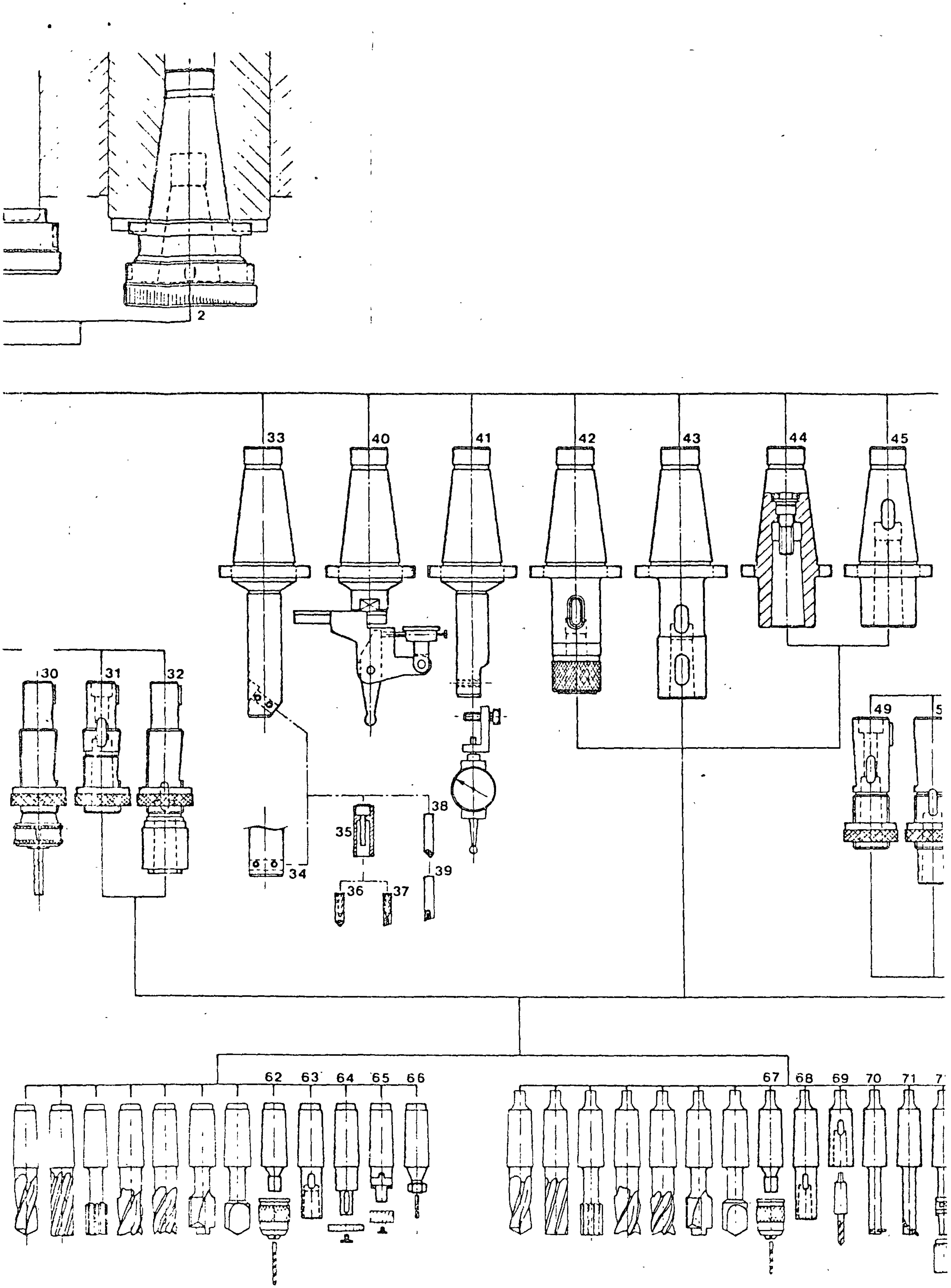
74.- Pinza de sujeción de cambio rápido para broca.

HERRAMENTAL PARA MAQUINAS DE CONT



ROL NUMERICO

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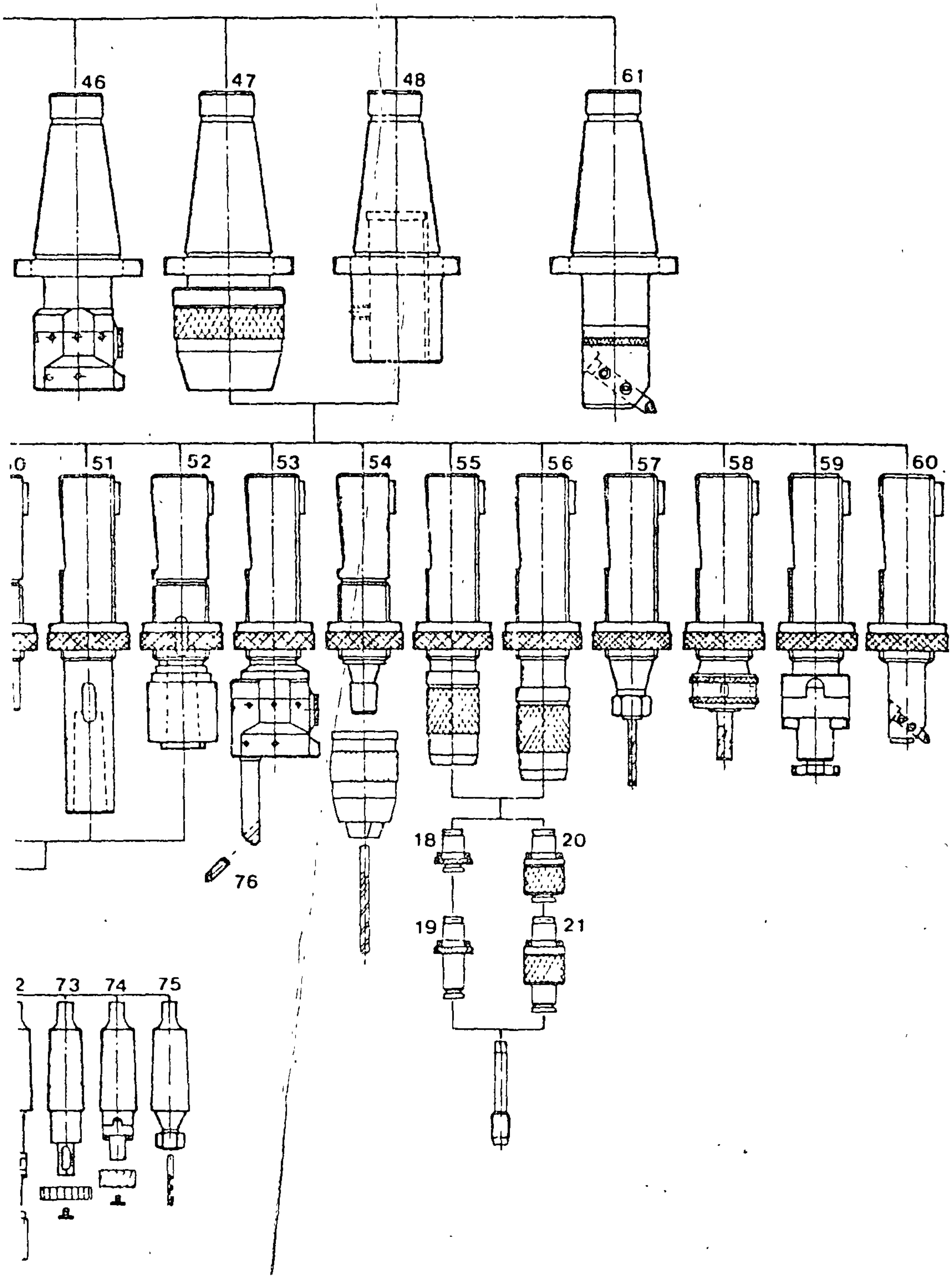
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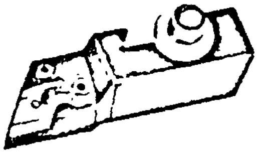
HERRAMENTAL PARA MAQUINAS DE CONTROL NUMERICO.

1.- Husillo principal. Accionamiento manual, mecánico ó hidráulico.
2.- Mandril principal accionamiento manual, mecánico ó hidraulico .
3.- Mandril porta cortador de disco con ajuste.
4.- Mandril porta cortador frontal con ajuste.
5.- Mandril porta cortador frontal.
6.- Mandril porta cortador de disco.
7.- Mandril de extensión porta cortador de disco.
8.- Mandril porta broquero.
9.- Mandril porta cabezal barrenador fijo.
10.- Cabezales mandriladores fijos.
11.- Mandril porta cortador vertical.
12.- Mandril porta cortador vertical con pinza de sujeción.
13.- Mandril porta cortador vertical con pinza de sujeción.
14.- Mandril porta cortador vertical, broca, rima con pinza de sujeción y tuerca.
15.- Mandril porta cortador vertical, broca, rima con pinza de sujeción y tuerca.
16.- Mandril porta cortador frontal.
17.- Mandril de cambio rápido para cabezas de machueleado.
18.- Cabeza de machueleado con control de torsión.
19.- Cabeza de machueleado con control de torsión.
20.- Cabeza de machueleado con control de torsión y cambio rápido.
21.- Cabeza de machueleado con control de torsión y cambio rápido.
22.- Mandril para adaptador de extensión
23.- Adaptador de extensión para cortador frontal
24.- Adaptador de extensión para mandrilado
25.- Adaptador de extensión con cabezal mandrilador ajustable.
76.- * Buril paramandrilado.
26.- Adaptador de extensión para broquero
27.- Adaptador de extensión para cabeza de machueleado.
28.- Adaptador de extensión para cabeza de machueleado.
29.- Adaptador de extensión para cortador vertical con pinza de sujeción y tuerca.
30.- Adaptador de extensión para cortador vertical con pinza de sujeción y tuerca.
31.- Adaptador de extensión a cono morse.

32.- Adaptador de extensión con cabeza flotante.
33.- Mandril para mandrilado.
34.- Cabeza micrómetrica.
35.- Sistema de ajuste.
36.- Buriles para mandrilado.
37.- Buriles para mandrilado
38.- Buriles para mandrilado
39.- Buriles para mandrilado
40.- Mandril para centrado
41.- Mandril para centrado
42.- Mandril porta-herramienta con cambio rápido.
43.- Mandril de extensión y reducción ISO a morse.
44.- Mandril de reducción ISO a Morse con tornillo de tracción
45.- Mandril de reducción.
46.- Mandril con cabeza micrometrica para mandrilado
47.- Mandril hidraulico para adaptador de extensión con cambio rápido.
48.- Mandril para adaptador de extensión con tornillo de sujeción.
49.- Adaptador de extensión.
50.- Adaptador de extensión con proyección.
51.- Adaptador de extensión con proyección.
52.- Adaptador de extensión con cabeza flotante.
53.- Adaptador de extensión con cabezal micrométrico.
54.- Adaptador de extensión para broquero
55.- Adaptador de extensión para cabezas machueleadoras.
56.- Adaptador de extensión para cabezas machueleadoras
57.- Adaptador de extensión para cortador vertical con pinza de sujeción y tuerca.
58.- Adaptador de extensión para cortador vertical con pinza de sujeción y tuerca.
59.- Adaptador de extensión para cortador frontal.
60.- Adaptador de extensión para mandrilado
61.- Mandril para mandrilado con cabeza de cambio rápido.

HERRAMIENTAS DE CAM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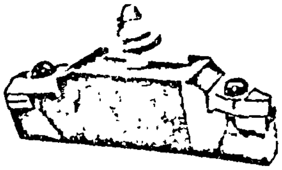
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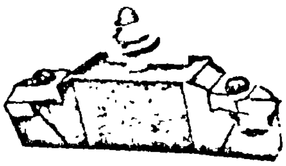
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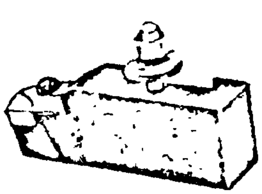
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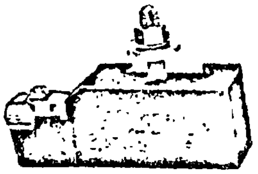
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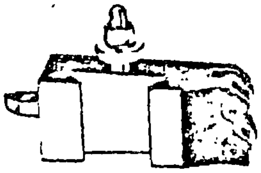
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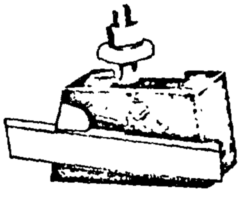
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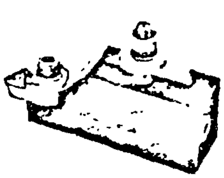
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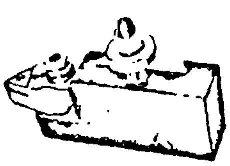
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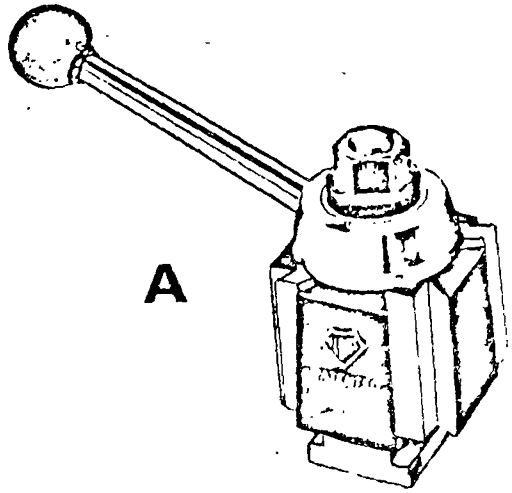
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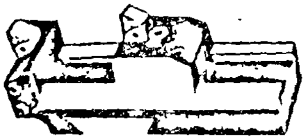
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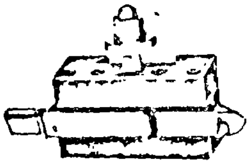
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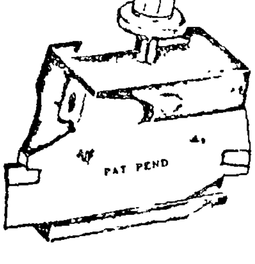

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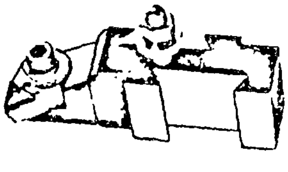
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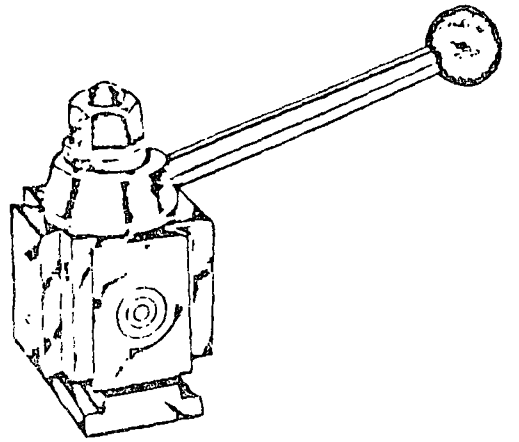

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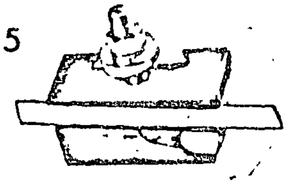

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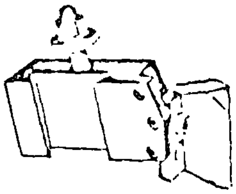

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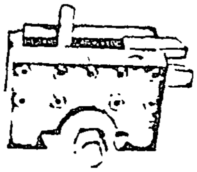

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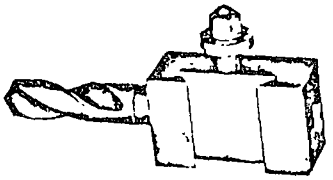

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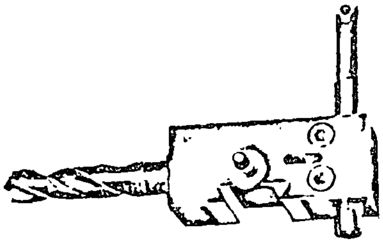

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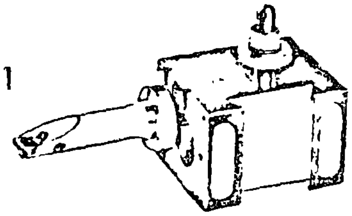

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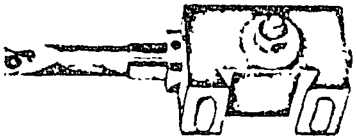

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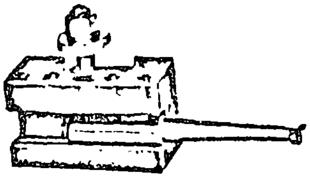

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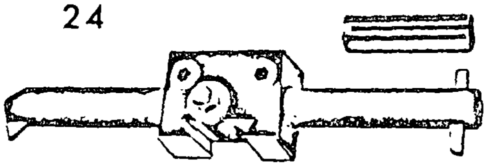

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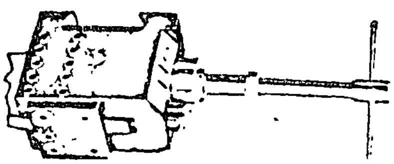

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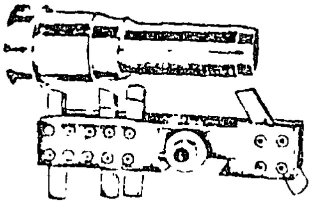

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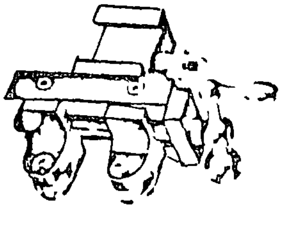
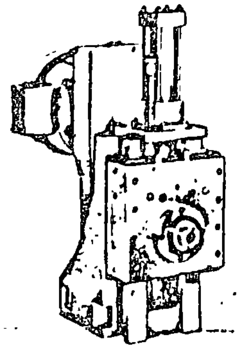


HERRAMIENTAS DE CAMBIO RAPIDO PARA TORNOS.

A y B Torreta de cambio rápido.

1.- Adaptador c/r para copiar
2.- Adaptador c/r con pastilla desechable careado, torneado, refrentado etc.
3.- Adaptador c/r con pastilla desechable careado, torneado, refrentado, etc.
4.- Adaptador c/r con pastilla desechable careado, torneado, refrentado, etc.
5.- Adaptador c/r con pastilla desechable careado, torneado, refrentado, etc.
6.- Adaptador c/r con pastilla desechable careado, torneado, refrentado, etc.
7.- Adaptador de c/r para engarruchar, ó moletear.
8.- Adaptador c/r para cuchilla de corte
9.- Adaptador c/r para roscar.
10.- Adaptador c/r para roscar.
11.- Adaptador c/r para tornear 2 diámetros.
12.- Adaptador c/r para cuchilla de corte con carburo.
13.- Adaptador c/r para cuchilla de corte con carburo.
14.- Adaptador c/r con cabeza movible
15.- Adaptador c/r para ranurar
16.- Adaptador c/r para roscar
17.- Adaptador c/r para roscar
18.- Adaptador c/r para buriles múltiples
19.- Adaptador c/r para taladrar
20.- Adaptador c/r para taladrar y mandrilar
21.- Adaptador c/r para barra de interiores
22.- Adaptador c/r para barra de interiores
23.- Adaptador c/r para barra de interiores
24.- Adaptador c/r para barra de interiores
25.- Adaptador c/r para buriles múltiples con ajuste
26.- Adaptador c/r para diámetros múltiples
27.- Adaptador c/r para rolar.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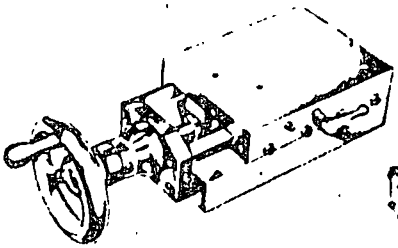
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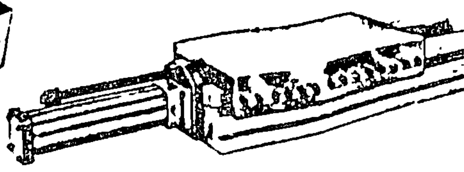
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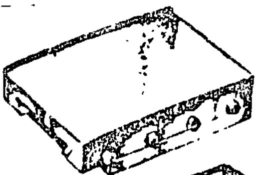
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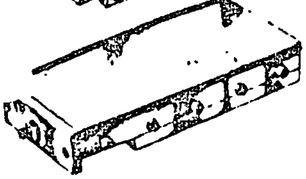
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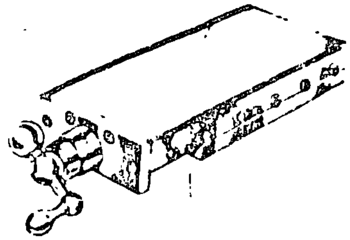
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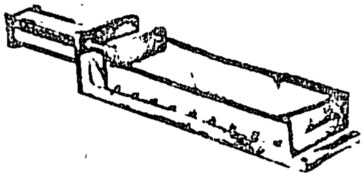

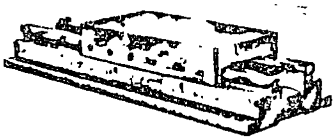
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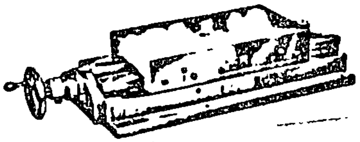
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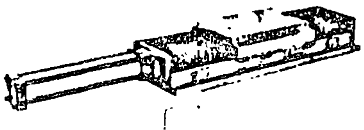
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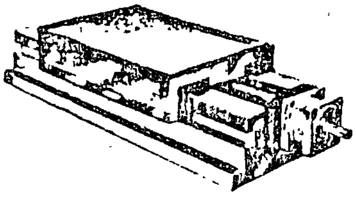
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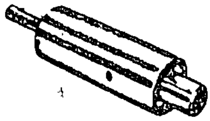
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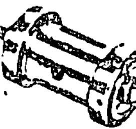
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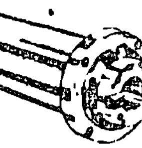
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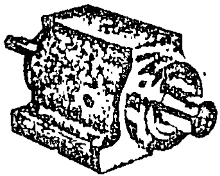
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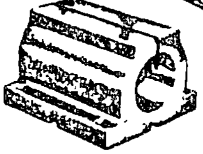
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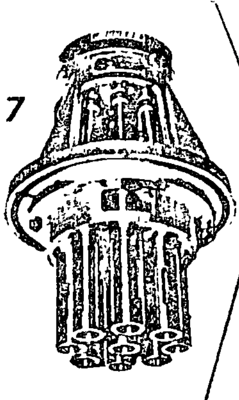
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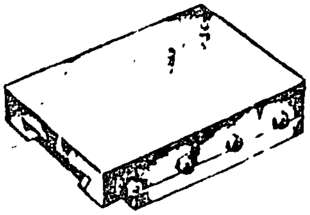

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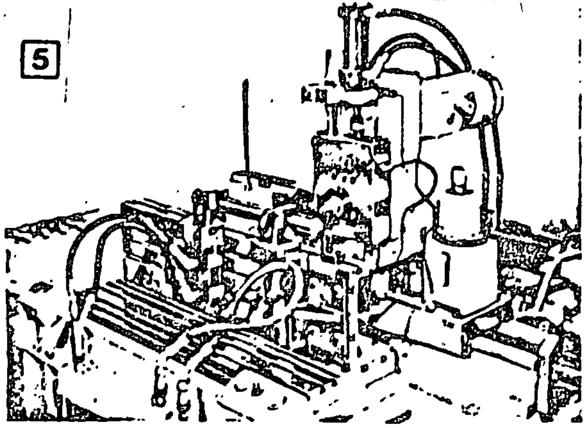

RICION DE MAQUINAS ESPECIALES

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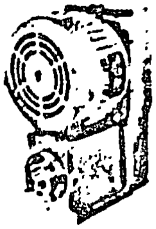

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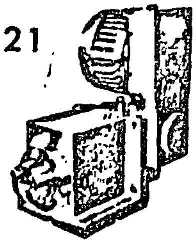

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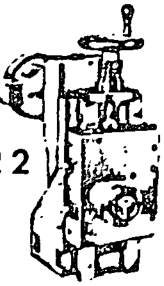

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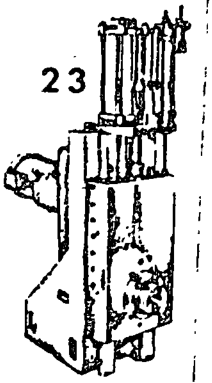

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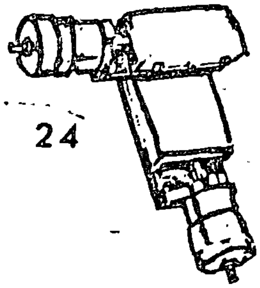

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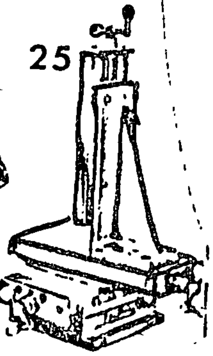

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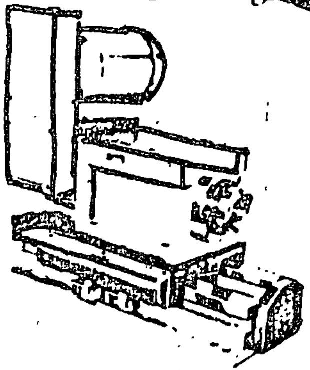

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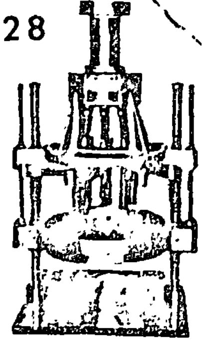
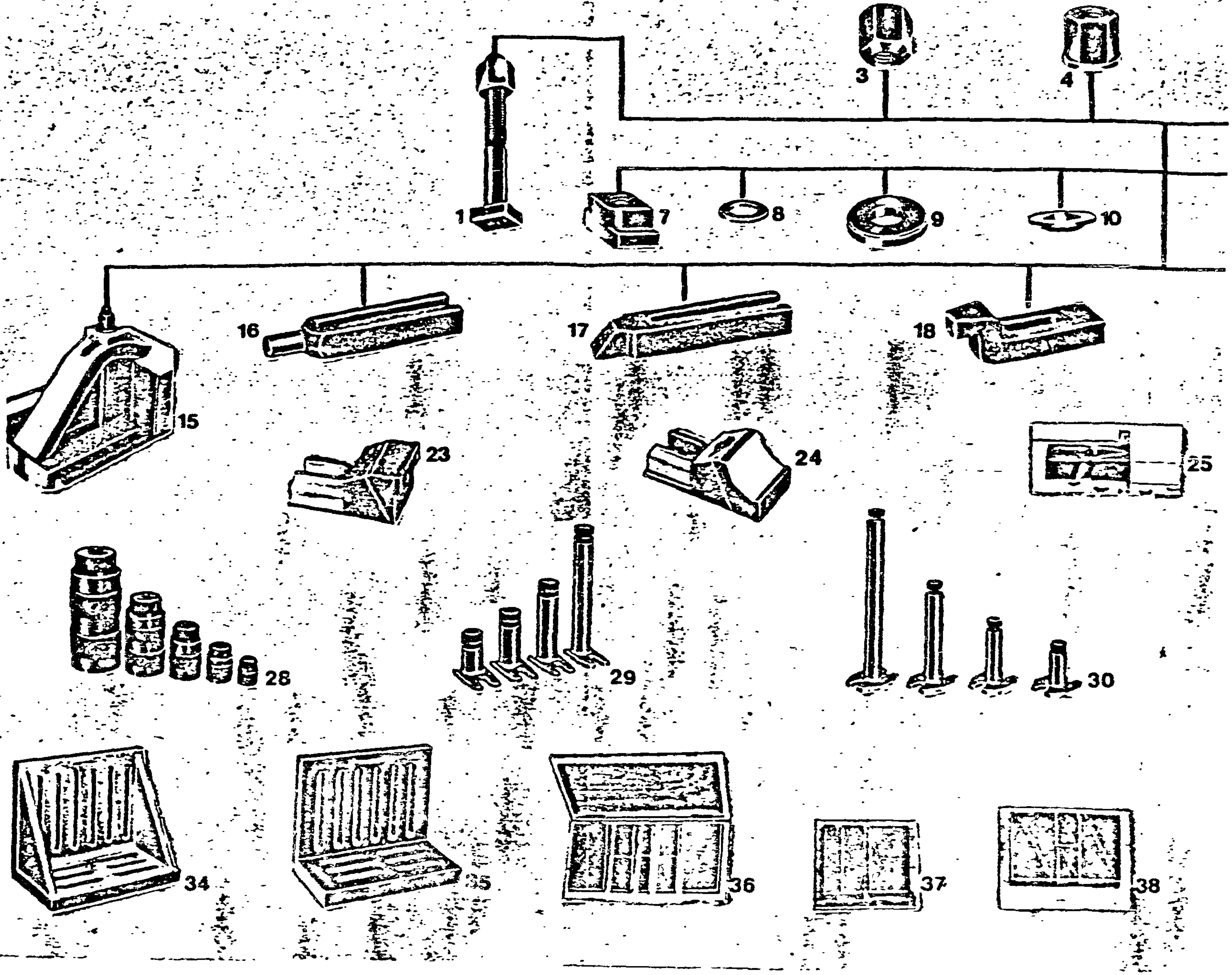
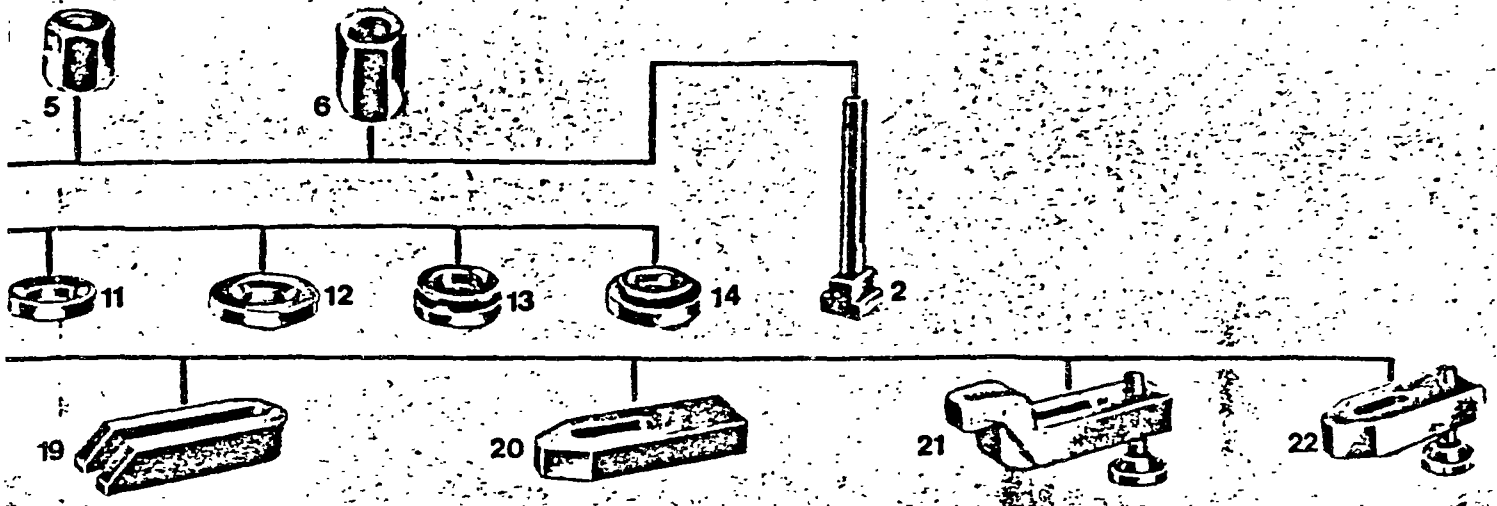
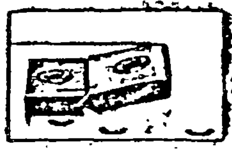


SISTEMAS DE SUJECION PARA MAQUIN



AS - HERRAMIENTAS - PRENSAS - ETC_

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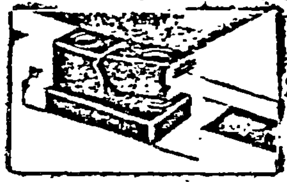
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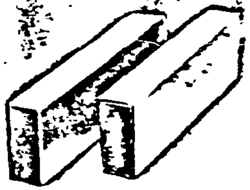
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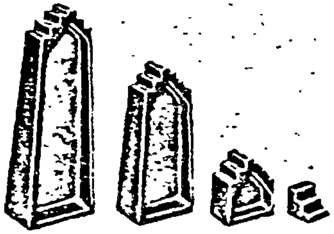
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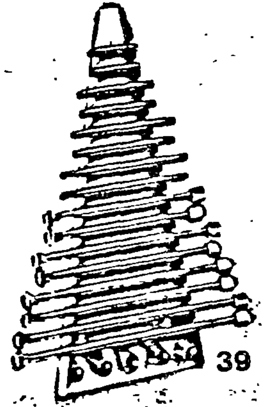
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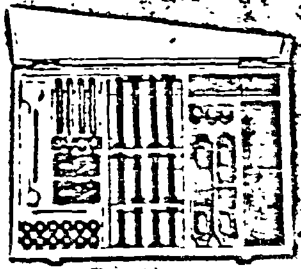
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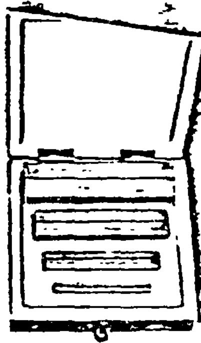
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SISTEMAS DE SUUECION PARA MAQUINAS HERRAMIETAS, PRENSAS, ETC.

1.- Tornillo T con tuerca
2.- Tornillo T sin tuerca
3.- Tuerca con punta esfera
4.- Tuerca con roldana
5.- Tuerca plana
6.- Tuerca alta
7.- Tuerca T
8.- Roldana
9.- Roldana plana
10.- Roldana capuchón
11.- Roldana esférica
12.- Roldana doble esférica
13.- Juego roldanas esféricas
14.- Juego roldanas doble esféricas
15.- Brida de gancho, tornillo T y tuerca con roldana plana.
16.- Brida diapason punta cilindrica.
17.- Brida diapason punta cónica.
18.- Brida cuello de ganzo.
19.- Brida U
20.- Brida apoyo
21.- Brida cuello de ganzo con tornillo de altura.
22.- Brida apoyo con tornillo de altura.
23.- Tope lateral.
24.- Tope lateral.
25.- Brida cuña
26.- Brida calza
27.- Brida calza con blocks de apoyo
28.- Apoyo ajustable
29.- Apoyo ajustable con base
30.- Apoyo ajustable con base
31.- Calzas
32.- Calzas escalonadas
33.- Blocks calzas.
34.- Escuadra ranurada de fijación con refuerzo.
35.- Escuadra ranurada de fijación.

36.- Juego de bridas escalonadas.
37.- Juego de bridas escalonadas.
38.- Juego de bridas escalonadas.
39.- Birlos de extensión
40.- Juego de birlos.
41.- Juego de sujetadores
42.- Juego de blocks calzas.

SUPER

MAQUINAS ESPECIALES PARA LAS PRODUCCIONES EN SERIE.

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1978
MEXICO D.F.

MAQUINAS ESPECIALES PARA LAS PRODUCCIONES EN SERIE.

GENERALIDADES.

Las máquinas para empleos generales no se prestan para las producciones en serie porque los elementos a trabajar, en este caso, requieren una sucesión ordenada de fases a desarrollar al mismo tiempo. Las máquinas especiales son las que desarrollan al menos dos de las siguientes operaciones diferentes entre sí: taladrado, mandrinado, cilindrado, refrentado, achaflanado, fresado, roscado, etc., según un ciclo automático. Se diferencian, por tanto, de las taladradores múltiples, mandrinadoras múltiples, fresadoras múltiples, etc., las cuales, como ya hemos visto, cumplen iguales operaciones mecánicas. Las máquinas especiales están estudiadas expresamente para realizar un determinado ciclo de trabajo que debe repetirse constantemente por un número indefinido de veces. Un principio fundamental, a tener presente al proyectar estas máquinas, es el de hacer, en lo posible, nulos los tiempos pasivos de montaje y desmontaje de las piezas de los utilajes. Ello se podrá realizar fácilmente cuando sea posible efectuar dichas operaciones pasivas durante el desarrollo de la fases de trabajo de herramienta; en otros términos: es necesario tratar de imponer la condición de cubrir los tiempos pasivos con los activos.

Si al proyectar estas máquinas se tiene en cuenta emplear cabezales operadores unificados, resulta también de menos preocupación la inversión de capital, por cuanto los mismos cabezales podrán utilizarse para futuras construcciones en otras máquinas. En este campo la técnica moderna se orienta también hacia la construcción de bancadas unificadas de dirente tamaño, además de los cabezales unificados, (Ver sección de Elementos Modulares estandar para la construcción de máquinas especiales para alta producción). De este modo es posible hacer las oportunas composiciones constructivas, lo mismo de bancadas que de cabezales, para componer máquinas diferentes unas de otras en función a las distintas exigencias requeridas, ya sea por la forma ó por el ciclo de trabajo de cada elemento a producir en serie.

....../.......
Cont.

Las máquinas pueden estudiarse de forma que se acometa un solo elemento al mismo tiempo por varias partes ó se acometan varios elementos a la vez por una sola parte, pero con operaciones progresivas. En el primer caso el elemento se coloca en el utilaje fijo y se somete a una serie de operaciones diferentes a la vez; en el segundo caso, donde generalmente se requieren utilajes giratorios, cada elemento sufre un arranque de material cada vez que pasa bajo la herramienta; pero ya que en el utilaje giratorio van colocados varios elementos, atacados progresivamente por varias herramientas, resulta evidente la simultaneidad de las fases, por lo que en la estación libre del utilaje se desmontan uno ó varios de dichos elementos terminados y se montan otros nuevos. La elección del sistema según el cual debe construirse la máquina está en relación a la forma geométrica de la pieza, de sus dimensiones, de la producción y del número de fases de trabajo.

Antes de proyectar estas máquinas es absolutamente indispensable estudiar el ciclo de fabricación y el modo de realizar las operaciones en el menor tiempo posible. En base a estos elementos se podrá llegar a la determinación del número de las herramientas que deberán actuar al mismo tiempo, al tipo de máquina especial, al número de estaciones del utilaje giratorio (si deberá elegirse este sistema)-, etc.

MAQUINAS OPERADORAS MULTIPLES CON UTILAJE GIRATORIO DE ESTACIONES.

Se debe producir en gran serie un elemento igual al representado en la figura 1. Se trata de un contrapeso de fundición y sirve para una máquina de coser. Según lo dicho ya en el párrafo anterior, es necesario estudiar, en primer lugar, el ciclo de fabricación adecuado. La figura 2 muestra la sucesión de fases que producen la pieza en el menor tiempo posible. Resulta evidente la necesidad de efectuar la elaboración en dos partes opuestas diametralmente, por lo que es necesario invertir la pieza en la estación de carga y descarga. Las fases ilustradas en la figura 2 son realizables a la vez mediante el empleo de un utilaje especial giratorio de estaciones (fig. 3) montado sobre la base de la máquina. Si examinamos las dos últimas figuras observamos:

Estación I. Fase la. Desmontaje del contrapeso montado derecho (D) y montaje del mismo a la derecha en posición invertida (C); montaje de una nueva pieza a trabajar en posición derecha (D) en el sitio libre.

Estación II. Fase 2a. Agujereado Ø 12,5 de la pieza montada derecha (D); la pieza invertida (C) no sufre ninguna operación.

Estación III. Fase 3a. Agujereado Ø 8,5 de la pieza montada derecha (D); la pieza invertida (C) no sufre ninguna operación.

Estación IV. Fase 4a. Refrendado de desbaste del tubo correspondiente al agujero pequeño de la pieza invertida (C); fase 5a. refrentado de desbaste del cubo correspondiente al agujero grande de la pieza - derecha (D)

Estación V. Fase 6a. Avellanado del borde del agujero Ø 8,5 de la - pieza invertida (C); fase 7a. avellanado del borde del agujero Ø 12,5 de la pieza derecha (D).

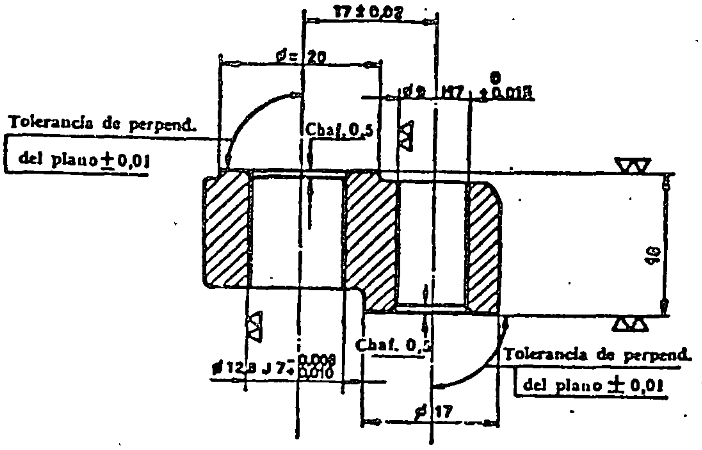
Estación VI. Fase 8a. Refrentado de acabadó del cubo correspondiente al agujero pequeño de la pieza invertida (C); fase 9a. refrentado de acabado del cubo correspondiente al aguero grande de la pieza derecha (D).

Estación VII. Fase 10a. Mandrinado a Ø 12,8-J7 con un mandril de dos cuchillas de agujero de la pieza derecha (D); la pieza invertida (C) no sufre ninguna operación.

Estación VII. Fase 11a. Mandrinado a Ø 9-H7 con mandril de dos cuchillas del agujero de la pieza derecha (D); la pieza invertida (C) no sufre ninguna operación.

La máquina que realiza este ciclo de fabriación está representada en la figuro 4. Se compone esencialmente de la base A, montante B, frente al cual va emplazada la unidad operadora automática C (tipo UFM-2), que lleva el cabezal múltiple F de 10 husillos con las herramientas adecuadas para realizar las fases según se ha indicado en la figura 2. Cada uno de los husillos gira según un determinado número de revoluciones, a fin de asignar a cada herramienta la velocidad de corte deseada. El cuerpo D, fijado sobre la base A, lleva en su parte superior la mesa E giratoria de ocho estaciones (véase figura 3). Dicha mesa va fijada entre dos montantes G y G1, en cuya parte superior está situada la plantilla H guía-herramientas (Ver sección de componentes herramentales para dispositivos y plantillas). La unidad operadora realiza automáticamente una carrera rápida de aproximación, una carrera normal de pasada y una carrera rápida de retroceso. Las piezas a mecanizar se colocan en los correspondientes utilajes montados sobre la plataforma giratoria, la cual, por cada carrera de la unidad operadora, gira automáticamente según un determinado ángulo y presenta todas

FIGURA 1.- CONTRA PESO DE FUNDICION.



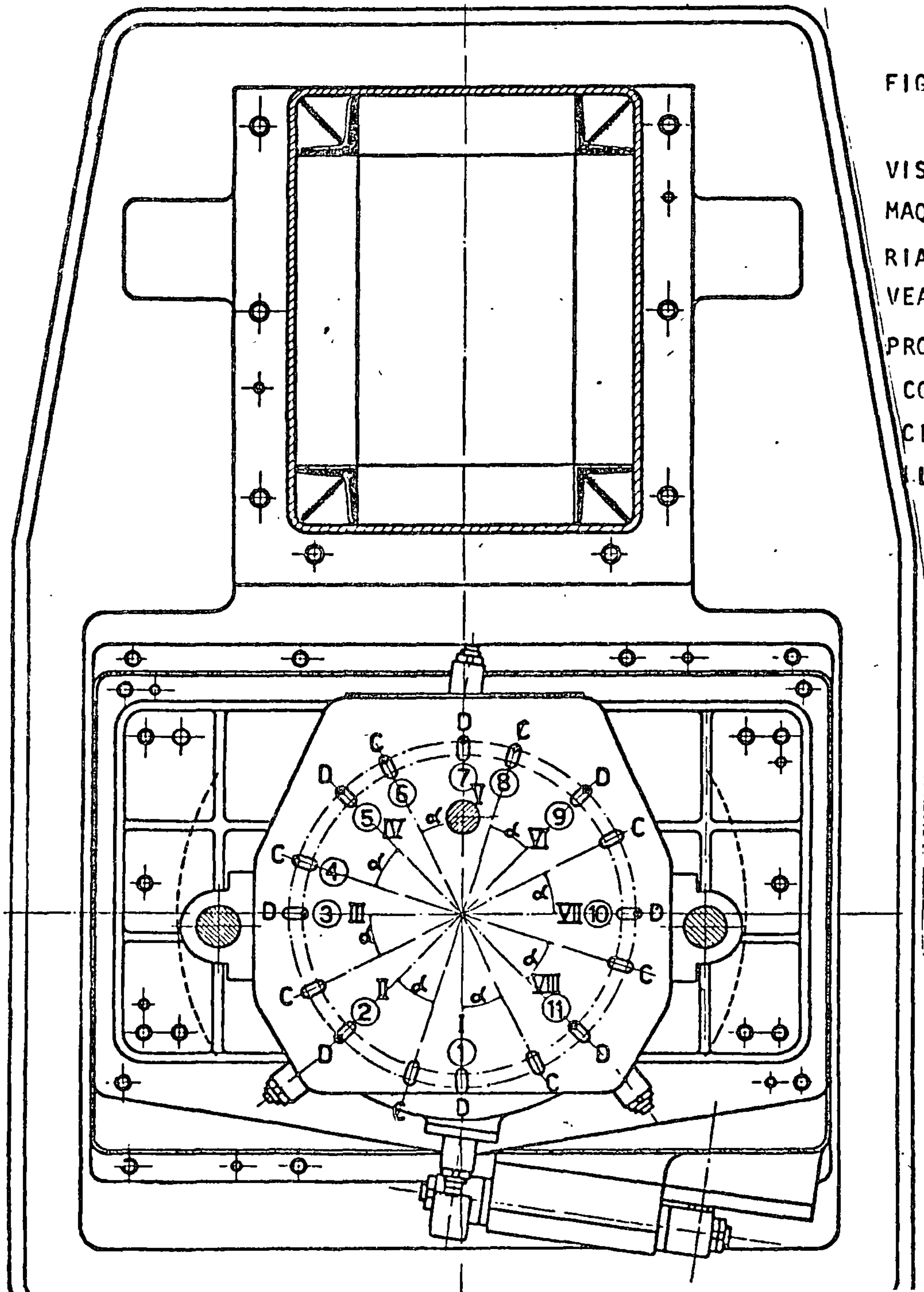
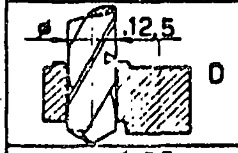
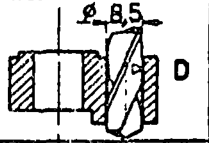
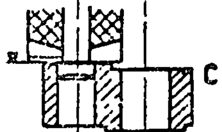
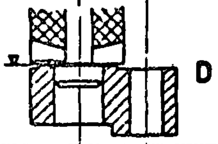
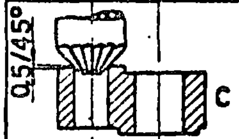
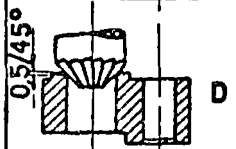
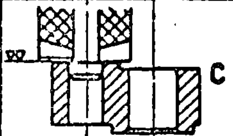
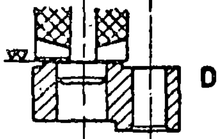
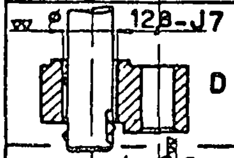
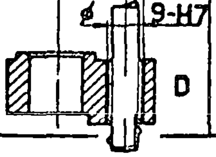


FIGURA 3.-

VISTA EN PLANTA DE LA MAQUINA Y MESA GIRATORIA DE OCHO ESTACIONES VEASE FIGURA 2 PARA PRODUCIR EN SERIE EL CONTRAPESO DE FUNDICION REPRESENTADA EN LA FIGURA 1.

FIGURA 2.- OPERACIONES DE MAQUINADO EN CONTRA PESO DE FUNDICION.

FIGURA D = derecha C = invertida	Estac.	Fase	DESCRIPCIÓN FASE	Revol. n 1'	Veloc. corte en m/1'	Avance mm/1 vuelta
	I	1ª	Carga y descarga piezas			
	II	2ª	Agujereado a ⌀ 12,5	690	27	0,102
	III	3ª	Agujereado a ⌀ 8,5	920	24,5	0,0765
	IV	4ª	Refrentado de desbaste del cubo pequeño	1035	55	0,0685
		5ª	Refrentado de desbaste del cubo grande	1035	65	0,0685
	V	6ª	Avellanado del filo del agujero ⌀ 8,5	1035	27,5	0,0685
		7ª	Avellanado del filo del agujero ⌀ 12,5	1035	40,5	00685
	VI	8ª	Refrentado de alisado del cubo pequeño	1035	55	0,0685
		9ª	Refrentado de alisado del cubo grande	1035	65	0,0685
	VII	10ª	Mandrinado a ⌀ 12,8-J-7	1883	75	0,0375
	VIII	11ª	Mandrinado a ⌀ 9-H7	2553	72	0,028

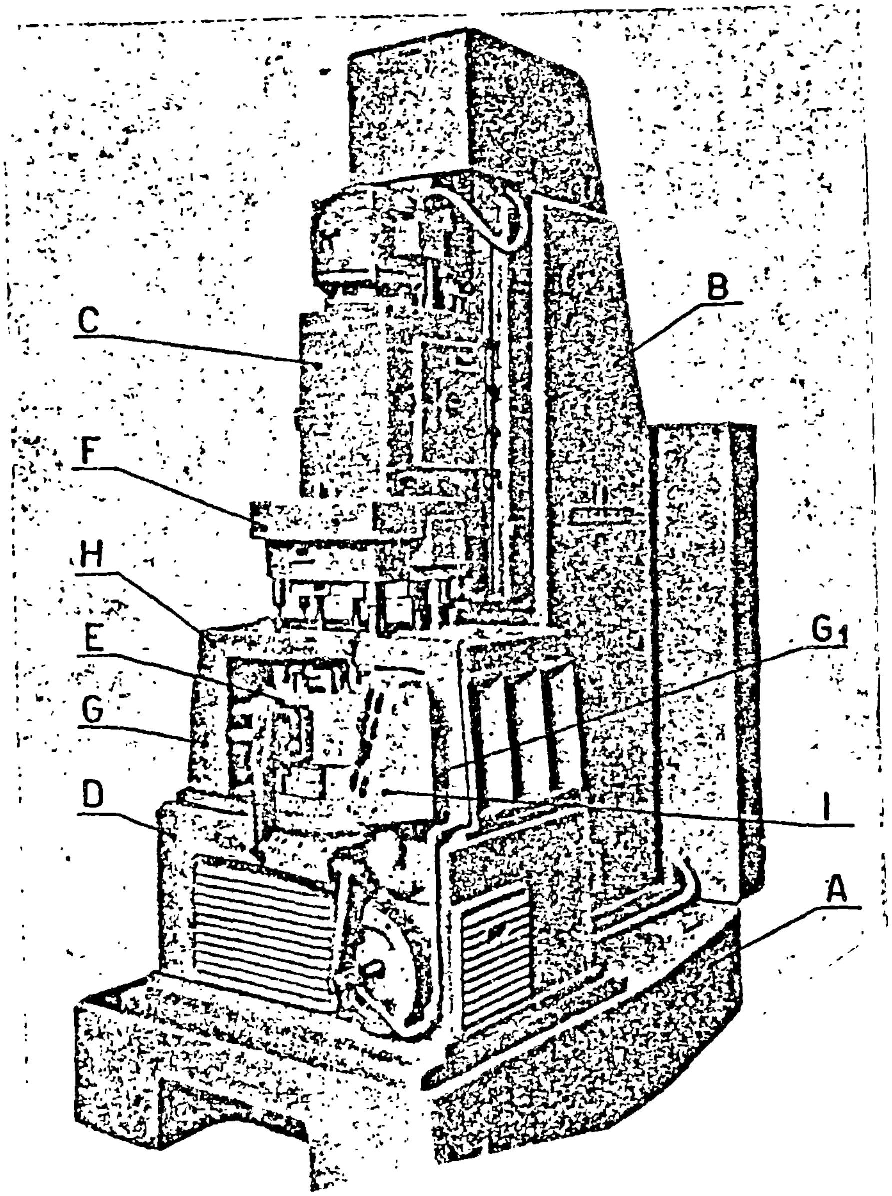


FIGURA 4.- MAQUINA ESPECIAL CON PLATAFORMA GIRATORIA PARA LA PRODUCCION EN SERIE DE UN CONTRAPESO DIBUJADO EN LA FIGURA 1.

las piezas frente a las herramientas en movimiento en operaciones sucesivas. Debido a que cada pieza debe ser necesariamente invertida, después de haber sufrido un giro completo con el utilaje sobre la plataforma, han sido dispuestos un número doble de utilajes portapiezas respecto al de las estaciones ó sea dieciséis, de los cuales ocho llevan las piezas derechas y ocho invertidas.

Por cada ciclo operativo se presentan dos utilajes correspondientes a la estación de carga y descarga; al mismo tiempo entra en acción un dispositivo neumático (Ver sección de componentes herramentales para dispositivos y plantillas), que suelta las dos piezas para ser extraidas: una de ellas, la smielaborada, es invertida y montada en el utilaje libre se monta una pieza en bruto. Es evidente, por tanto, que por cada giro de un octavo de un dispositivo de seguridad que impide el avance de la unidad hacia las piezas en el caso de que la mesa no se hallase en la posición exacta; esto se produce siempre que el obturador situado debajo no haya entrado exactamente en su asiento. Siempre que el ciclo fuera interrumpido por un motivo cualquiera (falta de corriente), los dispositivos de seguridad aseguran la repetición del ciclo desde el principio.

Los dispositivos eléctricos permiten hacer funcionar la máquina en las siguientes condiciones:

a) Avance del cabezal y rotación de los husillos.
b) Rotación de la mesa portapiezas.
c) Inserción del ciclo semiautomático, es decir, cambio de estación a efectuar voluntariamente con pulsador.
d) Inserción del ciclo automático continuo.
e) Posibilidad de poner a punto la máquina después de haber vuelto la corriente al circuito.

Los pulsadores para los distintos accionamientos están recogidos en el cuadro I.

A título informativo diremos que la potencia instalada es de 5 KW; el tiempo de máquina es de 21''; el tiempo para el giro de la mesa es de 7'' (la producción horaria media se puede considerar de 100 piezas); el número de revoluciones del husillo de la unidad n = 355 r.p.m. (giro a la izquierda) su avance a = 0,2/vuelta; el peso total de la máquina es de 5.000 kilogramos.

SUPER

GENERALIDADES SOBRE LAS FRESAS DE FORMA

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1978
MEXICO D.F.

Sección X

ESTUDIO DE LAS FRESAS DE FORMA.

Los cortadores destalonados a perfil constante.

Los cortadores de forma a perfil maquinado.

Una fresa de forma es aquella que reproduce en la pieza el perfil de su generatriz.

Por lo que cualquier fresa que trabaje girando es una fresa de forma mismo si su generatriz es una recta.

En general el perfil se compone de curvas y rectas tangentes ó no entre si. Puede ser cóncavo ó convexo.

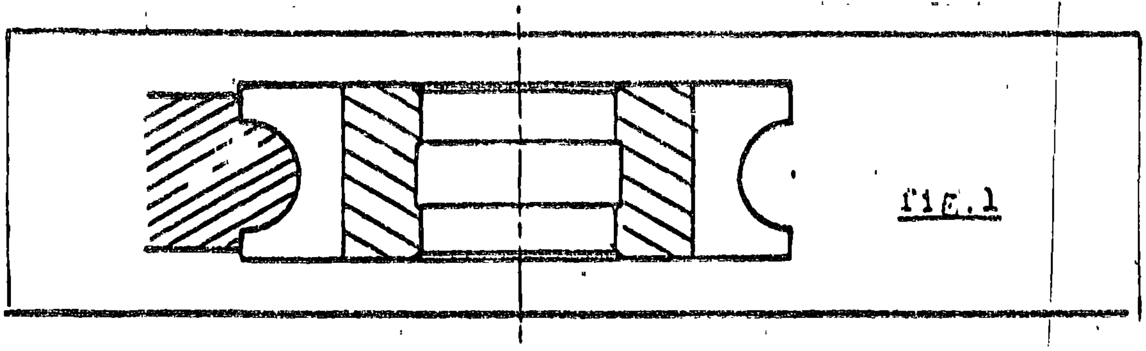


fig.1

Se dice que el perfil es cerrado si existe una ó varias -- tangentes perpendiculares al eje de la fresa ó muy cerca de ser perpendiculares; será de perfil abierto (fig. 2) en el caso contrario.

a) Perfil abierto (α y β) los ángulos minimos de las tangentes)

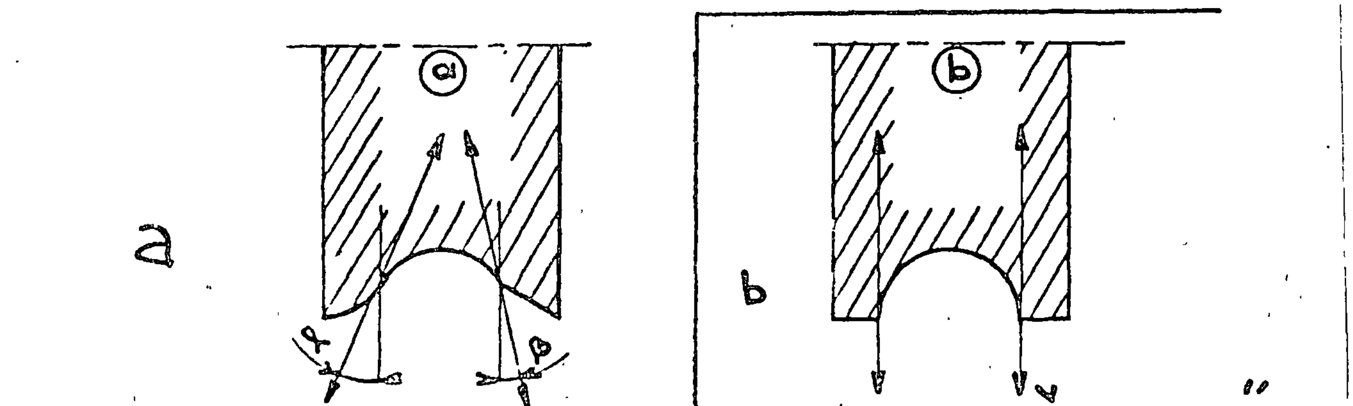
b) Perfil cerrado cóncavo.

c) Perfil cerrado convexo.

d) Perfil cerrado en un solo punto.

En ningún caso el perfil deberá presentar "entradas", es decir tal que una tangente perpendicular al eje corte al perfil en cualquier otro punto que el punto de tangencia. En esta cso el maquinado - de la fresa será extremadamente difícil y el perfil obtenido no sería - el de la fresa. (fig. 3)

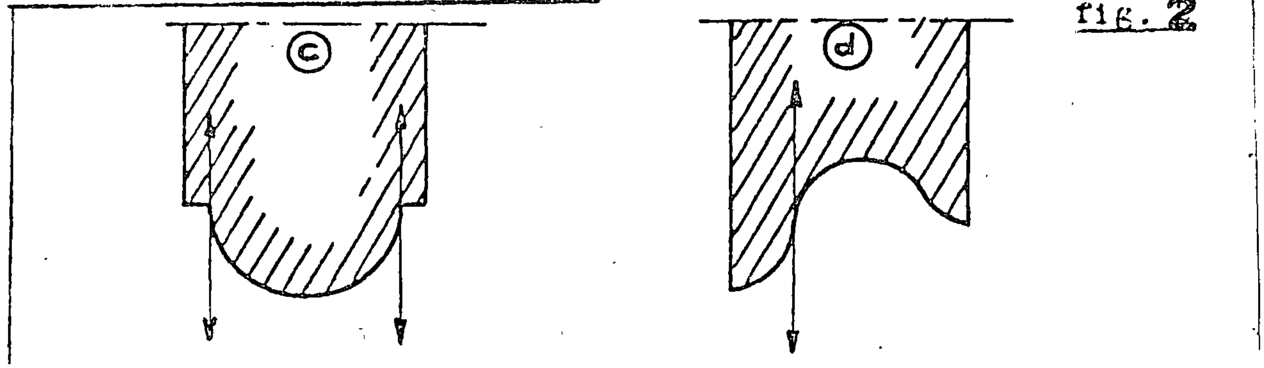
Se llaman <u>aristas frontales</u> del perfil aquellas que son paralelas al eje de la fresa y que por ésto su tangente es paralela ó casi paralela al eje de la fresa. Las otras aristas de corte pertenecen a las <u>aristas laterales</u>.



PERFIL "ABIERTO"
(α y β) SON LOS ANGULOS MINIMOS DE LA TANGENTE

PERFIL "CERRADO" CONCAVO

fig. 2



PERFIL CERRADO "CONVEXO"

PERFIL CERRADO EN UN SOLO PUNTO

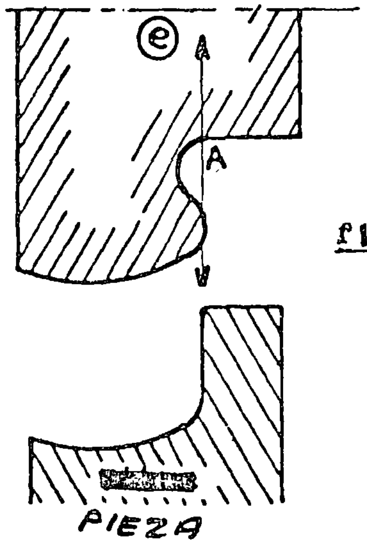


fig. 3

La existencia de perfiles más ó menos cerrados causan que la utilización de la fresas de forma sea más delicada ó difícil para los perfiles cerrados y que la producción que se obtenga de las mismas disminuya notablemente ya que para los puntos del perfil en donde la tangente esté perpendicular al eje ó casi perpendicular al mismo, las condiciones de corte son extremadamente malas.

Notemos desde ahora que el grueso de la rebaba es casi nulo en estos lugares, inferior a la rebaba mínima por lo que resulta imposible de -- cortar. La resistencia específica de la rebaba es muy elevada, por lo que se incrementan enormemente los esfuerzos de corte produciendose un mal acabado - de la superficie maquinada.

En el caso de fresas de forma con figuras de semicirculo existe el riego de acunamiento que puede resultar en la destrucción de la herramienta.

DISEÑO DEL CORTADOR O FRESA.

La forma de maquinar la pieza y por lo tanto el diseño del cortador evitan si esto se hace correctamente la creación de perfiles cerrados - aumentandose con esto el rendimiento y la vida de la herramienta.

No se trata de exponer aquí todas las posibles soluciones que -- puedan existir, pero un simple ejemplo ilustrara el problema.

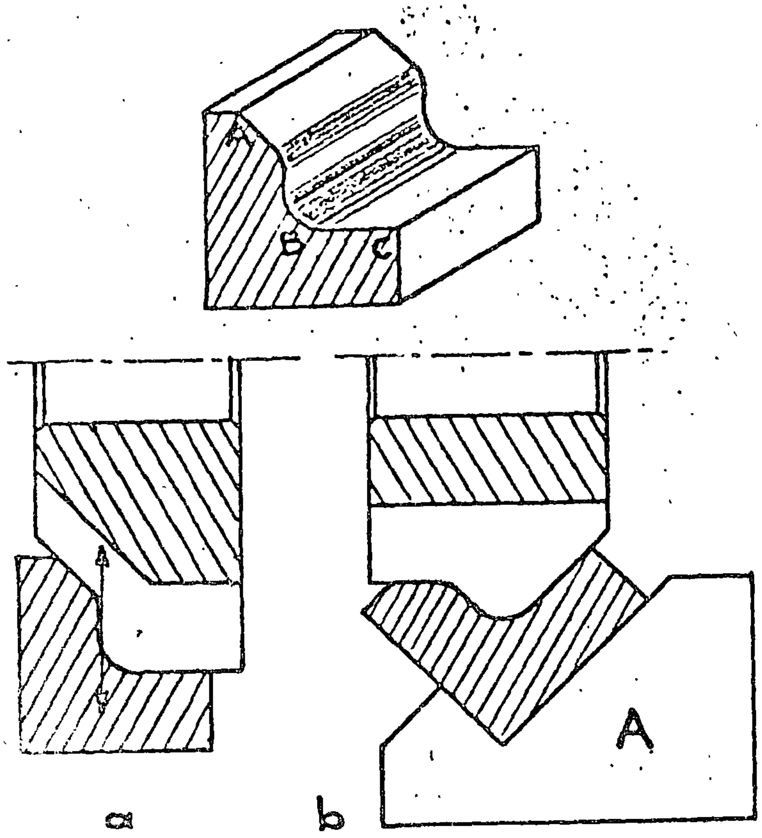
Supongamos que tenemos que fresar la forma A B C en una pieza (fig. 4)

Tendríamos entre otras dos soluciones:

Fig. 4a. La arista vertical del perfil y parte del radio inferior trabajan en muy malas condiciones.

Fig. 4b. La fresa trabaja en condiciones infinitamente superior ya que el perfil es abierto. Es necesario para ésto - inclinar la pieza (Sujección especial).

fig 4



CONDICIONES DE CORTE.

Es muy difícil estimar ó calcular las condiciones tan especiales y particulares en las que trabaja una fresa de forma, el poder definir de antemano los valores óptimos de velocidad y avance resulta casi imposible para cada aplicación particular y elaborar reglas generales sería aún más difícil.

Es también muy difícil de apreciar los esfuerzos que se producen y de estimar la potencia necesaria para el fresado.

En cada punto del perfil las condiciones de corte varían la velocidad de corte también, como lo ilustra la figura (5)

La suma de las resistencia específicas de la rebaba cambian. -- Los ángulos X1 y X2 no son los mismos y la sección "de" del perfil abandona la pieza antes que la sección "bo" haya terminado su trabajo.

Por lo que la cara de ataque de la fresa sufre esfuerzos variables y el conjunto de la fresa también.

Si nos detenemos bruscamente en una prosición de trabajo de uno de los dientes de la fresa (fig. 7) y si analizamos el metal que éste diente encuentre.

Enfrente de ella, vemos que las rebabas e y é en el instante considerado no son del mismo valor.

Vemos también que el resto de material a cortar varía a lo largo del perfil Q. El grueso de las rebabas laterales son más delgados cuando el ángulo Y e más pequeño. (El ángulo Y esta formado por la tangente del perfil al punto Q considerado y la perpendicular al eje de rotación de la fresa.

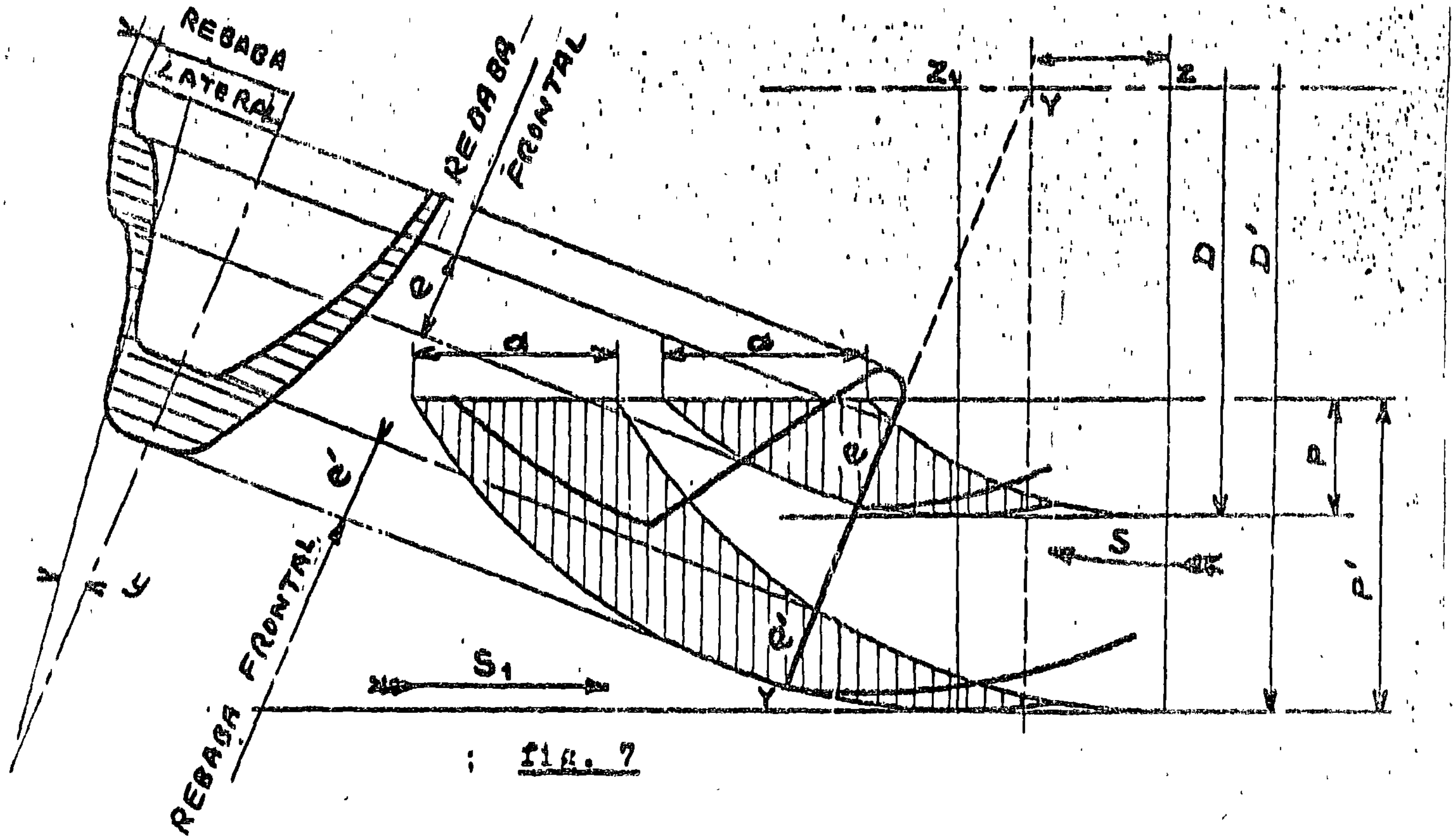


fig. 7

Si E^3 es el valor de la rebaba efectua frontal en el punto Q la rebaba lateral efectua en cuestion tendra por espesor E sobre Y.

Cuando Y = 0 (cero) el punto Q de la arista frota energicamente contra la pieza sin cortar ningún metal y la arista de corte se destruye en ese punto.

La rebaba así obtenida no se desarrolla, no se enrolla por lo que debe estamparse; su desprendimiento es difícil y hay riesgo de atoramiento con una gran absorción de potencia. Esta condición se reduce efectuando sobre las fresas de desbaste rompe virutas que seccionan ó dividen a la rebaba en bandas desarrollables.

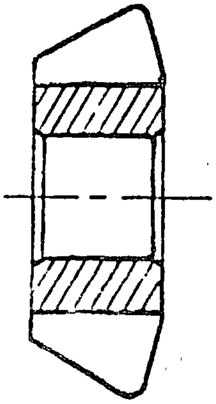
Estas condiciones también se reducen ó se mejoran cuando el -- perfil considerado a cortarse se desarrolla ó genera por una fresa de mayor diámetro. El mayor precio de ésta se compensa a veces por una mayor duración de utilización y por el mejoramiento de la superficie maquinada. La fresa es también más sólida.

PERFILES OBTENIDOS POR GENERACION:

La fresa de forma puede reproducir sobre la pieza cortada otros perfiles diferentes a los propies al trabajar por generación es decir al - "engranar" con la pieza animada de los movimientos apropiados ó adecuados.

El caso de los cortadores generadores de engranes "hols" es -- ciertamente el más conocido ya que al tener un perfil trapezoidal engendra dientes en envolvente de círculo. Pero las fresas - madres ó generadoras son herramientas a perfil constante esencialmente diferentes y muy distantes de las fresas de disco, de las cuales nos estamos ocupando en éste estudio.

Por ejemplo se realiza una generación por fresa de disco en el caso del fresado de las ranuras helicoidales. (fig. 8)



FRESA BICONICA

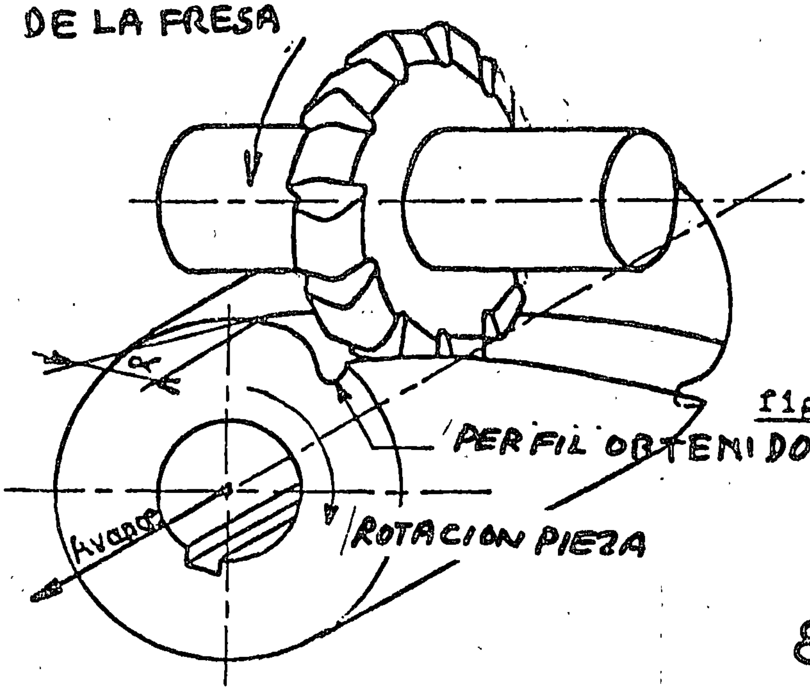


fig 8

8

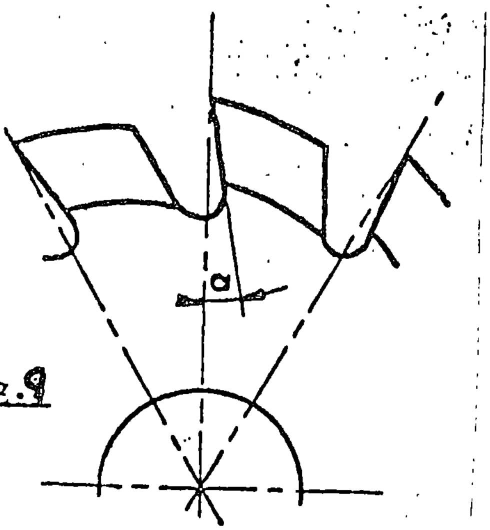


fig. 9

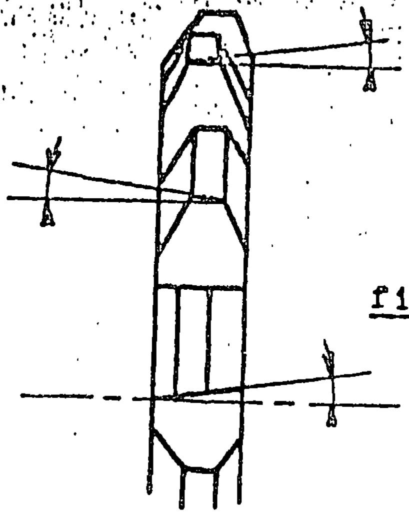


fig. 10

Además del movimiento de avance la pieza está animada de un movimiento de rotación que crea la hélice.

El perfil obtenido es muy diferente de el de la fresa.

Notemos que al cambiar el ángulo de la hélice (Al cambiar la velocidad de rotación con relación al avance) ó al cambiar la inclinación de la fresa vamos a cambiar la figura ó forma de la ranura obtenida.

El estudio y el analisis matemático de los perfiles es muy complicado. Es más acertado obtener los perfiles por ensayos.

Habiendo examinado las generalidades propias de todas las fresas de forma, vamos a detallar más particularmente los dos tipos de fresas de forma.

a) Fresas de forma DESTALONADAS a perfil constante.
b) Fresas de forma a perfil esmerilado, copiado a plantilla
A) Fresas de forma destalonadas a perfil constante.

Estas fresas son muy usadas ya que son de fácil uso y reafilado. Si se tienen ciertos cuidados de reafilado está uno casi seguro de la constancia (No variación de dorma) del perfil.

El perfil DESTALONADO de estas fresas se construye de una vez por todas en tomos llamados destalonadores.

Si se reemplaza la herramienta de forma por un esmeril cuidadosamente perfilado se puede rectificar el perfil después del temple.

El rectificado es necesario cuando se desea obtener un rendimiento mayor y también mejor precisión. El rectificado quita efectivamente todas las asperezas, rugosidades, capa descarbonizada y las pequeñas deformaciones debidas al temple. La arista de corte, ya no estará excéntrica y será más tersa, condiciones que favorecen la formación de rebabas delgadas cortadas por el perfil lateral.

Las fresas destalonadas rectificadas cuestan más caras ya que su precisión es más elevada pero duran más por lo que en ciertas aplicaciones resultan más económicas.

PENDIENTE DE AFILADO DE LAS FRESAS DESTALONADAS.

Es necesariamente nula para las fresad de precisión ya que un valor positivo de éste ángulo haría variar la longitud del perfil a medida que la fresa se fuera reafilando ya que esta disminuiría de diámetro.

Las fresas de forma destinadas a acabados precisos cortan notablemente menos que las fresas de desbaste.

Sin embargo las fresas de forma destalonadas que cortan contornos sin precisión ó que hacen desbaste (Dejando por ejemplo 1 mm. de material) pueden ventajosamente llevar una pendiente de afilado.

Esto sin embargo está pendiente de afilado solo existe en los lugares en donde la fresa quita rebabas frontales (fig. 9)

Para poder cortar más eficientamente las rebabas laterales que son las más delgadas, hay que afilar si se pueden la cara en forma de cuchilla (concava) con inclinación lateral (fig. 10) alternativamente un - diente hacia un lado el otro hacia el otro. (Para la cual se recomienda - fresa con un número de dientes pares) ó bién desarrollar otro método parecido.

NO deben diseñarse ó usarse fresas cuya cara de corte sobrepasa la línea de centros de la fresa. Esto destruye el perfil, da lugar a aristas de corte más obtusa que fatigan enormemente a la herramienta y - producen un trabajo defectuoso.

Analisis de la geometría de las fresas destalonadas.

1-) El ángulo de desbaste frontal V y el lateral g. (fig. 11)

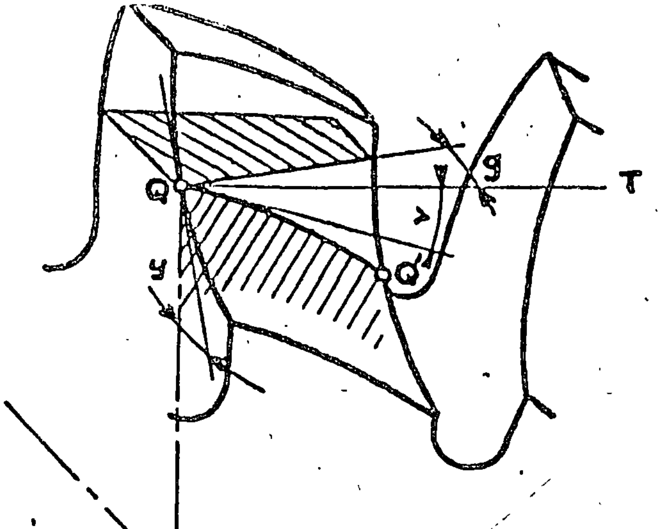


fig. 11

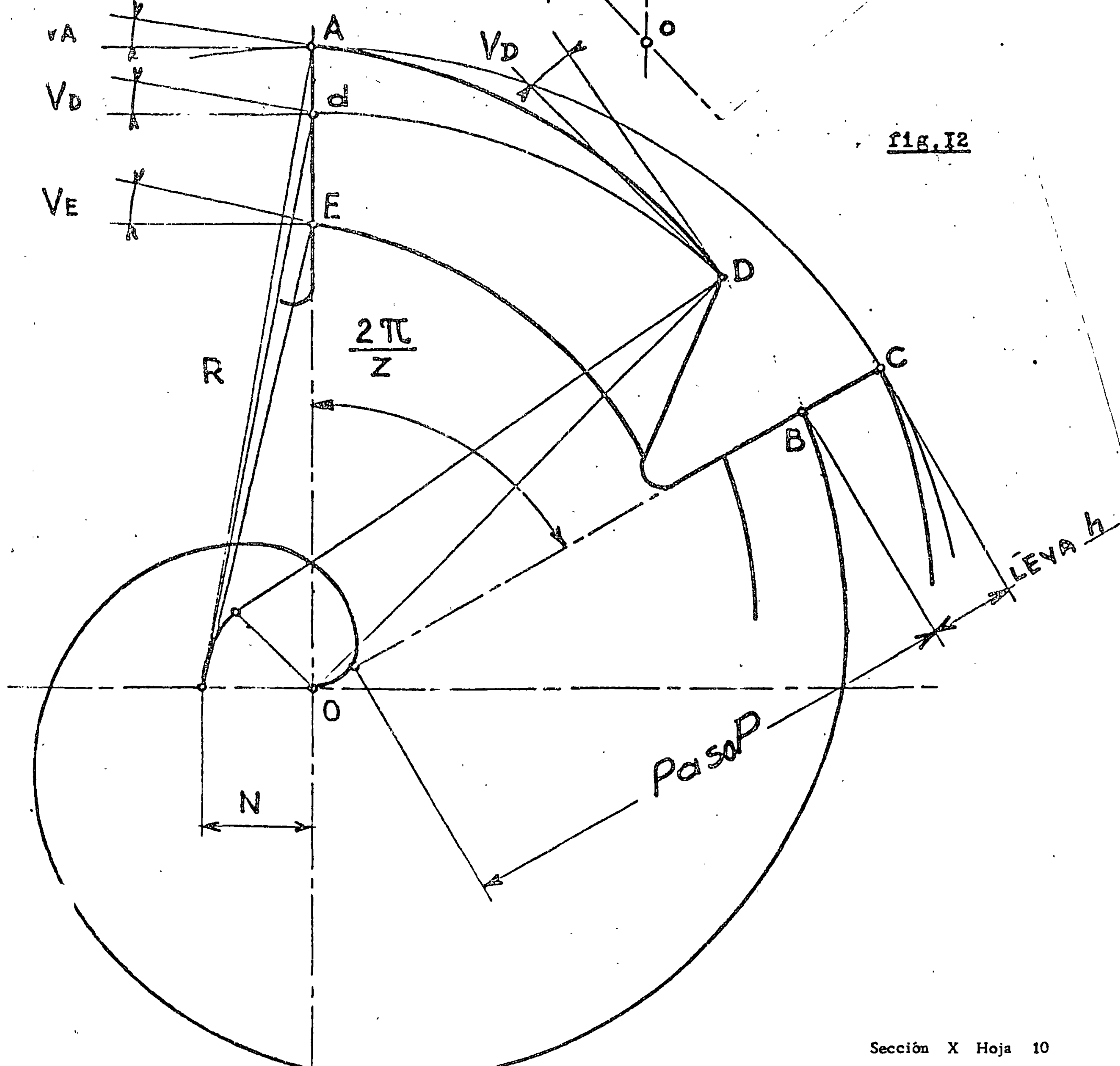


fig.12

Si en un punto Q del perfil cortamos el diente por un plano perpendicular al eje, obtendremos la curva QQ' hace en Q el ángulo V con la perpendicular Q T a la cara de ataque.

Es el destalonado frontal /Q.

Si cortamos el diente por medio de un plano paralelo al eje y -- conteniendo a Q T obtendremos el trapecio curvilíneo achurado en muestra el ángulo g de destalonado lateral en Q.

Entre V y g existe la relacion: $Tg\ g + Tg\ V \cdot Tg\ y$

2-) Curva de destalonado (fig. 12 a fin de que el ángulo de destalonado fronta V conserve su valor a medida que se reafila la fresa ó cortador $(VD = V_A)$

La curva AB debería ser teoricamente una espiral logaritmica.

Pero cualquier otra espiral paralela que paso por un punto E no sería ya una espiral logaritmica.

En la practica se reemplaza la espiral logaritmica por una espiral de Arquimedes y que se sobrepone casi exactamente sobre la longitud relativamente corta de un diente y que además se encuentra situada bastante - alejado del polo 0 de la espiral.

3-) Paso de la espiral altura de la leva.

La altura h de la leva provoca una penetración h de la herramienta de forma para una rotación de la fresa $\frac{2\pi}{2}$ 2 = número de dientes.

Para una revolución completa 2π de la fresa la penetración continua de la herramienta habria tenido por valor.

$$P = 2h$$

P es el paso de la espiral.

La leva siendo la misma para todos los puntos del perfil (ejemplo A y E) se concluye que todas las espirales son paralelas y tienen el mismo paso P.

4-) Angulo de destalonado frontal V

Su estudio se simplifica si notamos que la normal N de una espiral de Arquimedes es constante para todos los puntos de esa espiral e igual a:

$$N = \frac{P}{2 \pi} = R \tan V$$

ésta fórmula nos muestra también que permanece la misma para todas las espirales de paso P es decir para todas las espirales del perfil.

De esta fórmula obtenemos el valor del destalonado frontal.

$$\tan V = \frac{P}{2 \pi R} = \frac{Z h}{2 \pi R}$$

P y π siendo constantes V varia entonces con R.

El examen de la figuro 12 nos muestra claramente que V_A, V_E y V_D son todos diferentes ya que todos fueron construidos a partir del perfil posterior ha sido rebajado sobre la arista.

Es por esto que en una fresa nueva V toma valores diferentes en cada punta de la arista de corte VA y VE.

Es más cada uno de estos valores cambia a medida que se va reafilando la fresa y que VA se convierte en V_D

La fórmula Tan g = Tan V seno Y mostrada anteriormente nos muestra las variaciones de V repercutiendo sobre el destalonado lateral g acentuandose ésta condición por la forma del perfil ($_Y$ ángulo de la tangente)

Para tener un fresado correcto V no deberia de pasar de 120° al mismo tiempo que g no disminuyera abajo de 3° . Lo que supere la condición necesaria pero no suficiente Y 140°

Mayor que

Es indispensable entonces verificar los valores de V y sobre todo de g en cada caso particular.

FORMULAS PRACTICAS APROXIMADAS.

Evitando el uso de tablas trigonometricas para el desarrollo de las fresas destalonadas.

Para los ángulos inferiores a 140° tenemos.

$\text{Seno } a \cong \text{Tan } a \cong 0.0175\, a^\circ \quad a \quad 140^\circ$

Las fórmulas antes mencionadas se escriben entonces:

$\text{Tan } V = \frac{Zh}{2\pi R}$ se convierte en $V^\circ = \frac{Z\,h}{0.11\, R}$

$\text{Tan } g = \text{Tan } V \cdot \tan Y$ se convierten en $g^\circ = 0.0175\, V^\circ\, Y^\circ$ (los ángulos se expresan en grados y decimales)

E J E M P L O S :

Un punto Q de un perfil de una fresa ó cortador de 11 dientes.

$R = 38$ mm. $y = 3^\circ$

La leva de destalonado es de $h = 6$ mm.

Destalonado frontal

$V^\circ = \frac{11 \times 6}{0.11 \times 38} = 15^\circ\ 79$ sea $15^\circ\ 47'$

$g^\circ = 0.0175 \times 15^\circ\ 79 \times 3 = 0^\circ\ 83$ sea $0^\circ\ 49'$

En este punto el destalonado frontal es muy grande y el destalonado lateral insuficiente (recordar que no debe ser menor en ningún caso de 3°) Por lo que habra vibración y frotamiento.

En tales casos si no se puede ni aumentar Y modificando el perfil - de la fresa ó el diseño de la misma empleando distintos valores de h Z R se debe tratar de obtener otro tipo de solución rentable ya sea recurrir a una fresa resistente que consuma grandes cantidades de potencia y deje un acabado -- mediocre con poco rendimiento por parte de la fresa.

AFILADO DE LAS FRESAS DE FORMA DESTALONADAS.

El desgaste de la fresa ó cortador se produce sobre la cara de ataque por la acción de frotamiento de la pieza maquinada principalmente en los - puntos del perfil lateral en donde el destalonado es mínimo.

De que se observa sobre el perfil del diente un "liston" de desgaste, brillante ó rayado que alcanse un ancho de 0.10 a 0.15 mm. el reafilado se impone. Es más fácil económico y correcto reafilar la fresa en ese instante - que tratar de hacer unas cuantas más malas pasadas que dejaran en la pieza un mal acabado y también pueden destruir la fresa.

Hay que distinguir 2 tipos de fresas de forma destalonadas.

1-) Fresas de forma destalonadas a perfil rectificado
2-) Fresas de forma destalonadas a perfil no rectificado

1-) Fresas de fierro destalonadas a perfir rectificado.

La división (Espaciamiento de los dientes) de éstas fresas de precisión debe ser conservado. La mejor forma es de utilizar un divisor de precisión.

Existen máquinas de reafilado automáticas diseñadas especificamente para ese trabajo.

Si no se dispone de este tipo de máquina debera usarse una afiladora universal en buen estado con una piedra de esmeril de grano 60 u 80 dureza I ó J.

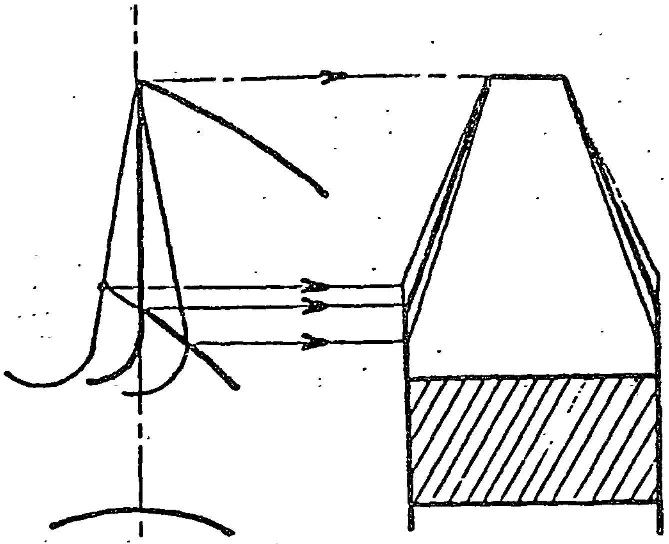


fig. I5

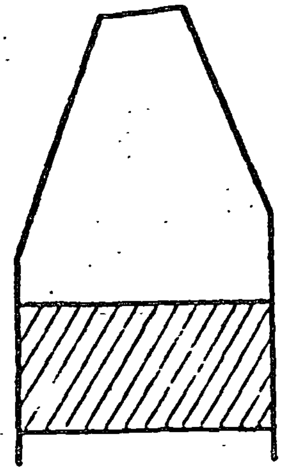


fig. I6

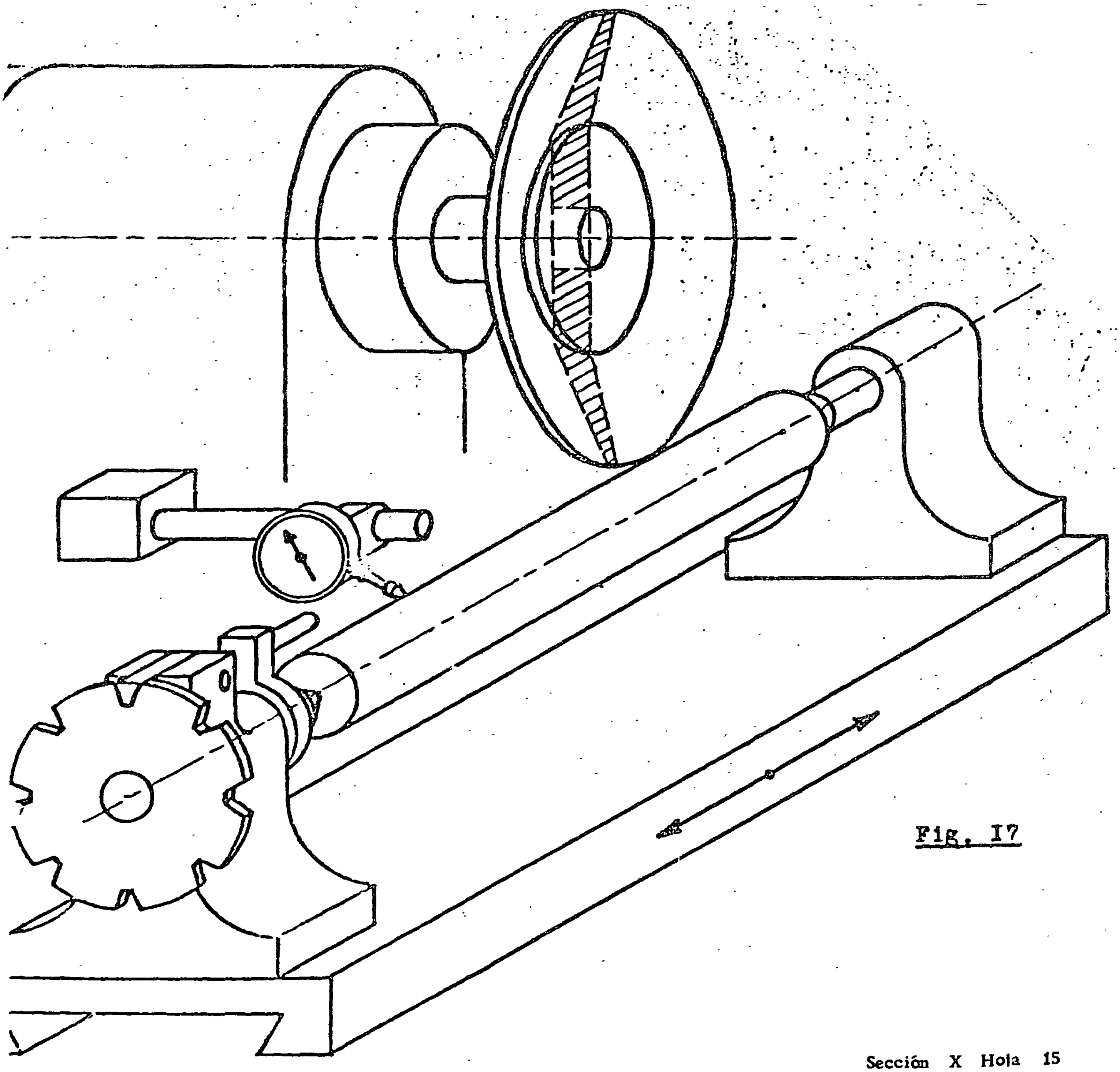


Fig. I7

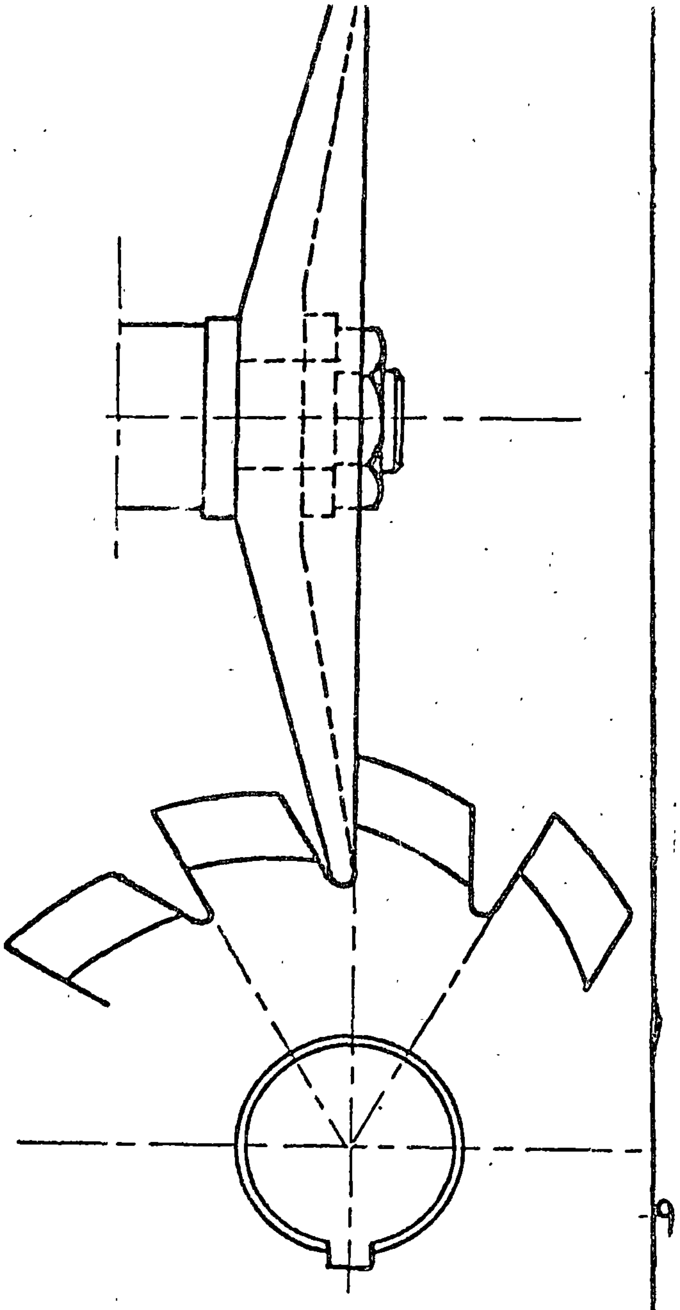


FIG 18

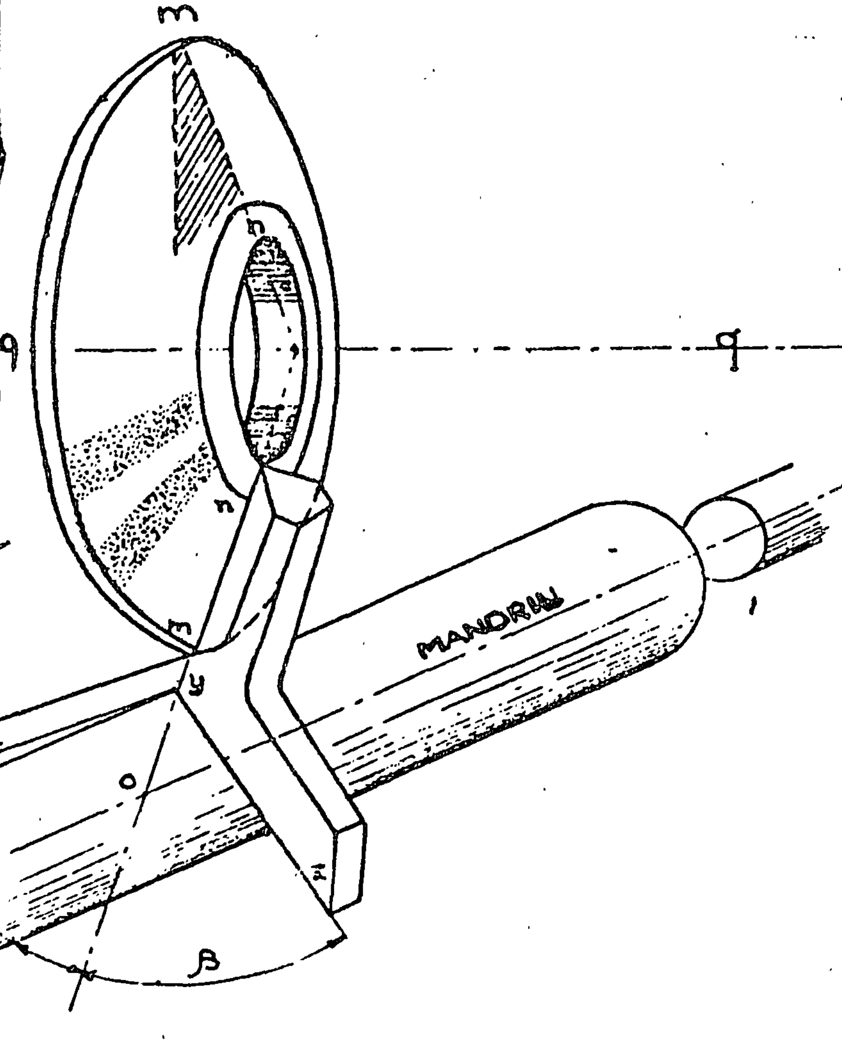


fig. 19

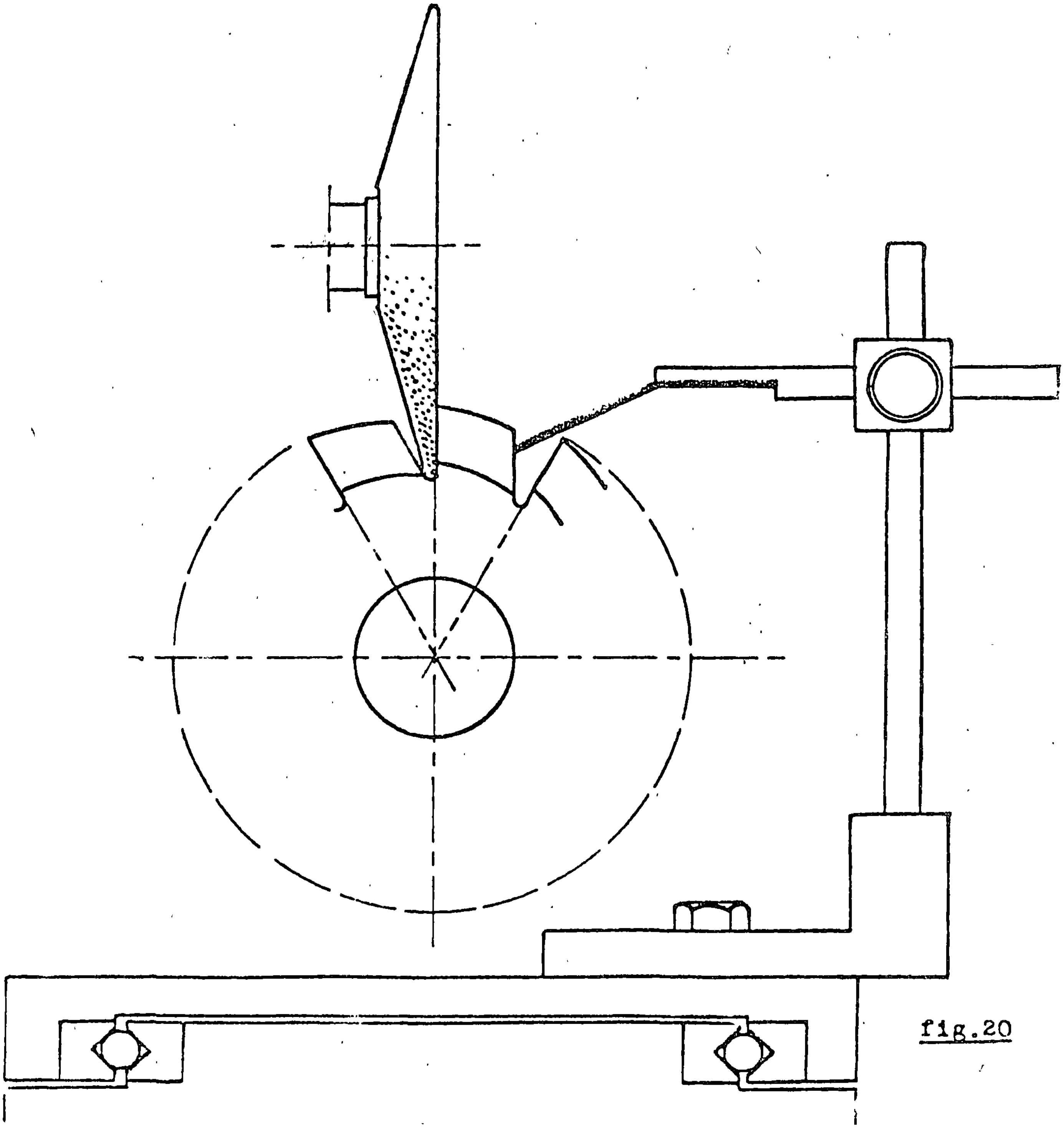


fig.20

Se puede utilizar el respaldo cónico de la piedra ó mejor todavía, para dentados rectos la circunferencia exterior.

La fresa se montará sobre un mandril preciso (Lectura total del indicador .0002") entre centros.

Es indispensable que el reafilado se haga rigurosamente radial y paralelos al eje a fin de no correr riesgo de deformar el perfil de la fresa.

Un afilado positivo (fig. 15) alarga el perfil, un afilado negativo reduce, no paralelo al eje lo distorciona (fig. 16)

Hay que vigilar que el afilado sea plano sobre toda la altura del perfil y que el radio de trabajo este bastante debajo del perfil.

Estas diferentes condiciones que desfiguran el perfil deben evitarse con un correcto montaje de la máquina.

CONDICIONES DE MONTAJE CORRECTO DE LA MAQUINA.

a) (fig. 17) Montar el mandril entre centros.
(Checar con un comparador su paralelismo debe estar dentro de .0005/12")

b) (fig. 18) Ajustar el plano de la cara de la piedra con el eje de la fresa.

c) (fig. 19) Si se afila con el respaldo cónico de la piedra utilizar una plantilla de localización para poder colocar la generatriz según un eje de la fresa

Se deben hacer muchas pequeñas pasadas cambiando constantemente de diente.

NOTA IMPORTANTE:

Las fresas de forma destalonadas a perfil rectificado pueden y deben afilarse con un divisor. Las no rectificadas no (ver la siguiente sección).

Esto se debe a que después de temple la fresa se deforma es decir, no está concéntrica. Si se rectifica el perfil ésta condición se corrige pero si no se rectifica ésta condicion se corrige precisamente en el afilado.

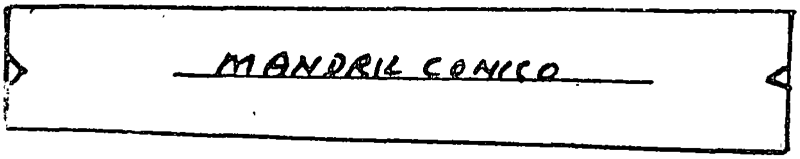
Fresas de forma destalonadas a perfil no rectificado.

No deben afilarse por medio de un divisor sino, empleando los métodos que a continuación se describen.

Se deben seguir las mismas precauciones en el montaje de la máquina que en la sección anterior.

PRIMER METODO.-

Se monta la fresa en un mandril de precisión entre centros y se rectifica cilindricamente (fig. 20)



Apoyando la fresa en la parte posterior contra un tope de afilado ajustable se va girando hasta que en cada diente desaparezca el listón.

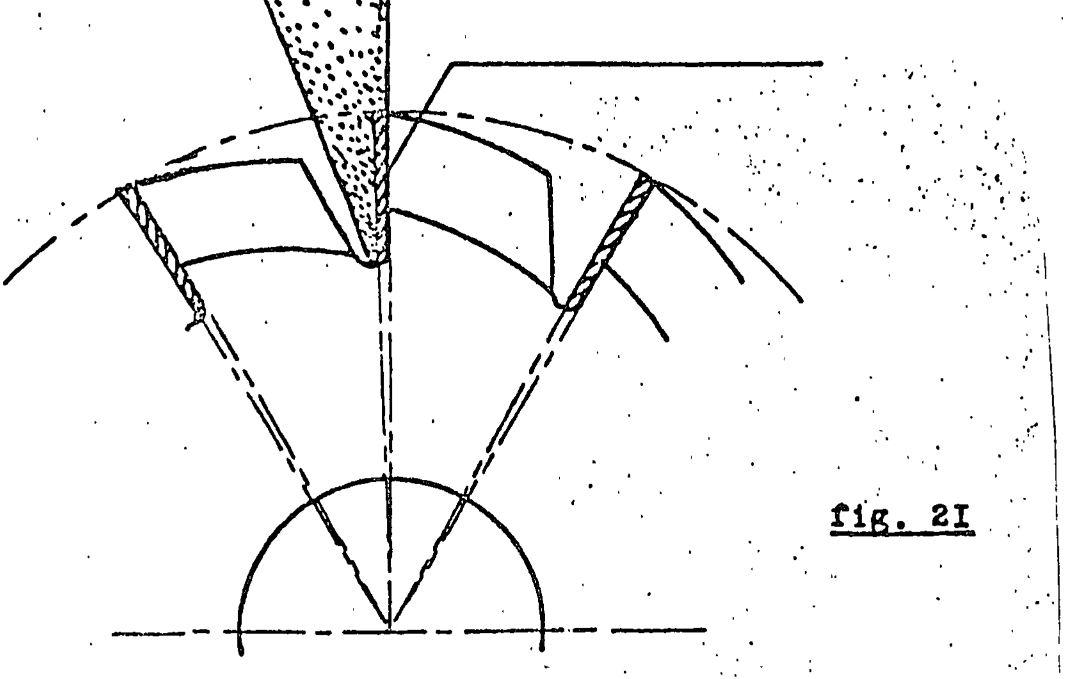


fig. 2I

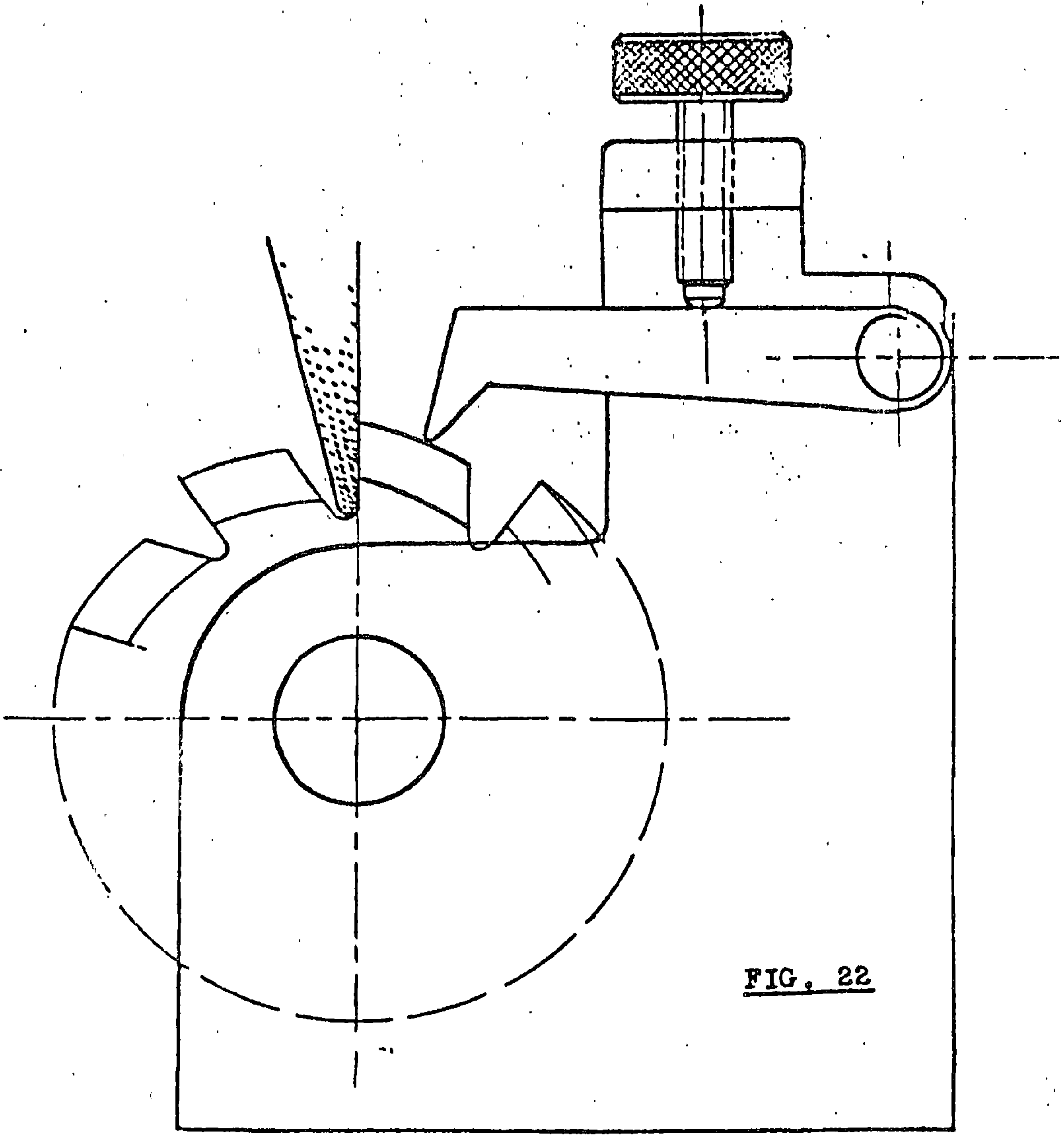


FIG. 22

Muchos fabricantes, especialmente las casa de prestigio después del primer afilado, esmerilan la parte posterior del diente apoyando cada diente sobre la cara afilada (fig. 20B)

Esto permite su reafilado apoyandose precisamente en la cara -- posterior y girando la fresa hasta que el liston de desgaste desaparezca, la fresa deberá checarse entre puntos con un comparador para saber si las aristas de corte de todos los dientes estan concéntricas con el eje de rotación (fig. 21)

Existen aparatos especiales para el reafilado de fresas destalonadas de forma de perfil no rectificado como el que muestra la fig. 22.

MODO DE OPERACION.

Se coloca la piedra en el eje de la fresa y la cara de ésta se hace coincidir con este eje. El diente de poyo (B) deberá entonces tocar al diente de la fresa. Al accionar el tornillo la fresa gira y se va -- afilando hasta que desaparezca el liston de desgaste.

Perfiles correctos e incorrectos de las fresas de forma destalonadas de perfil rectificado y no rectificado.

FRESAS DE FORMA A PERFIL CORTADO.

Estas fresas se asemejan a las fresas usuales en su diseño y - fabricación los dientes son fresados y luego afilados a la forma del perfil deseado. (fig. 25)

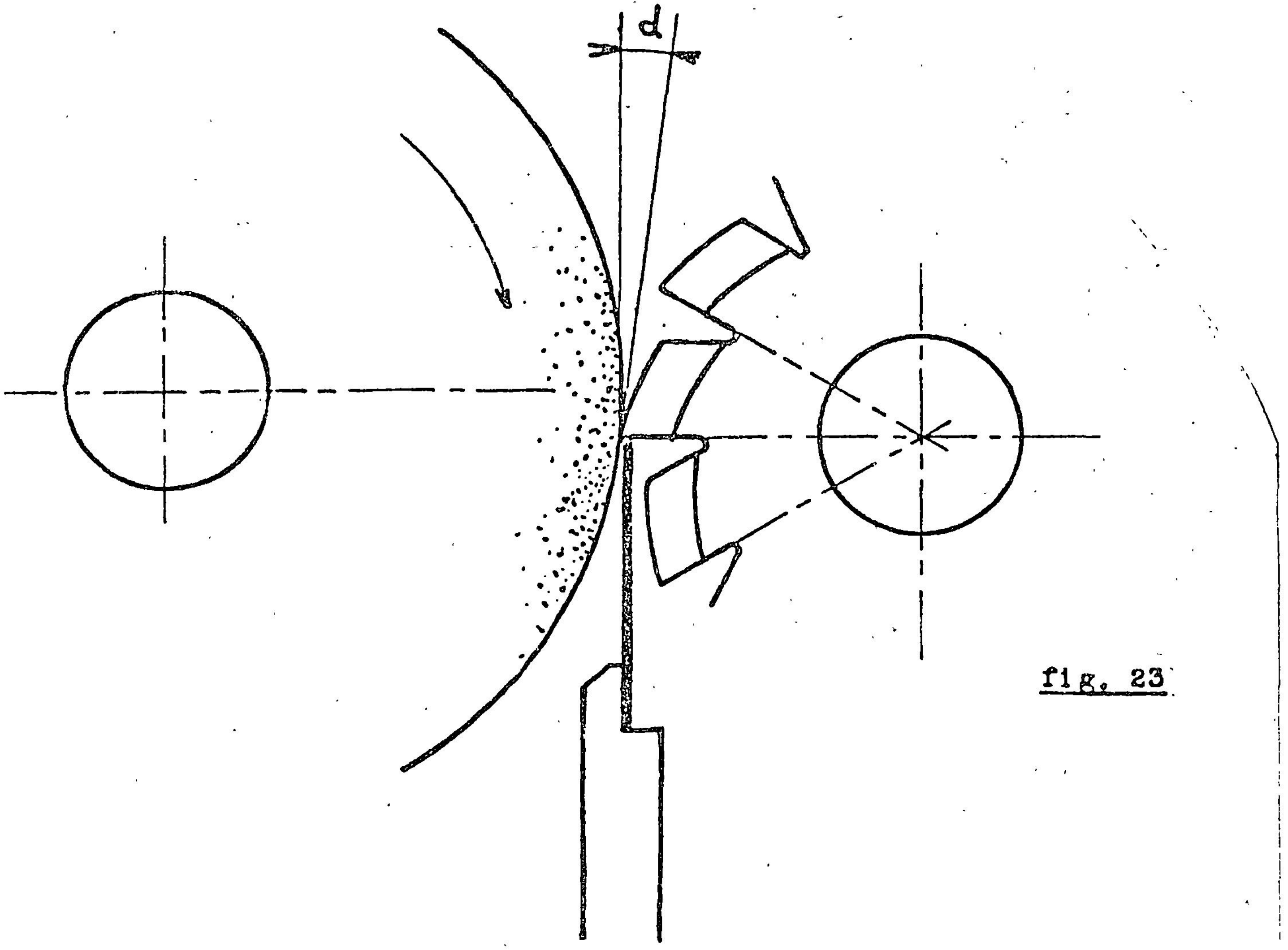


fig. 23

A fin de poder seguir el perfil de la fresa se requieren de fresadoras copiadoras especiales y de afiladoras copiadoras ó de plantilla.

La precisión del perfil tanto de fresado como de afilado dependerá de la precisión de la plantilla y de la repetibilidad y sensibilidad del copiado.

Las plantillas se construyen en acero templado en rectificadores de perfiles a comparador optico.

Para las curvas simples seguidas de tangentes se pueden emplear afiladora normales con un diamantador de forma (copia del que tenemos en la fábrica).

Las fresas cónicas ó bicónicas son fresas de forma a perfil cortado y su reafilado se efectua en máquinas comunes con piedras ó de tasa.

La forma se obtiene por el ajuste de los ángulos de afilado en la máquina misma.

La verificación del perfil se puede efectuar de varias maneras:

a) Por medio de transportadores y reglas
b) Por medio de una plantilla.
c) Por medio de un comparador optico.

En este tipo de fresa la forma es independiente del destalonado es entonces posible de afilar los perfiles frontales y laterales con los - ángulos correctos de corte (podrian llamarse también de destalonado pero - para evitar confusiones los llamaremos ángulos de salida) de acuerdo al tipo de material a cortar (Ver tabla I

Tabla 1 ángulos de afilado (salida) para cortar diferentes metales.

En estas condiciones la fresa a perfil cortado, cortará el material en mejores condiciones que una fresa de forma a perfil destalonado.

Afilado por medio de plantilla. Sus principios (fig. 26)

La fresa se coloca en rotación libre (se monta en un mandril de precisión entre centros ó en un mandril para afilado, en una boquilla ó cualquier otro metodo que le permita girar y presente la arista que se quiera afilar) sobre un cono deslizante al que se le monta una plantilla de lámina con el perfil que se desea afilar.

Esta plantilla se coloca "a plomo" de la generatriz de la fresa y tiene una escala 1 a 1 con la forma exacta que se desea afilar.

Este carro (A) puede desplazarse.

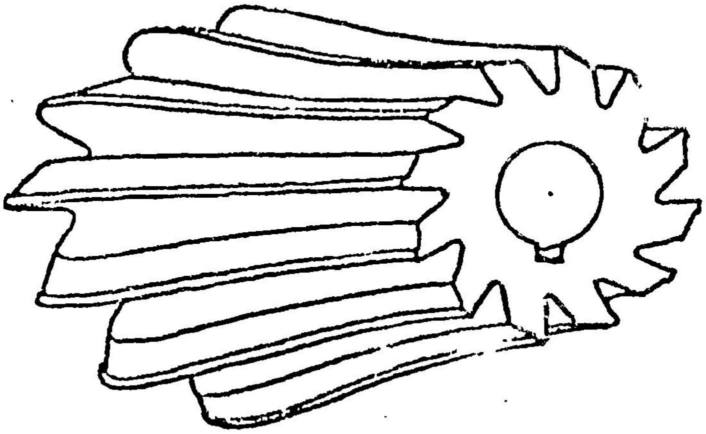


fig. 25

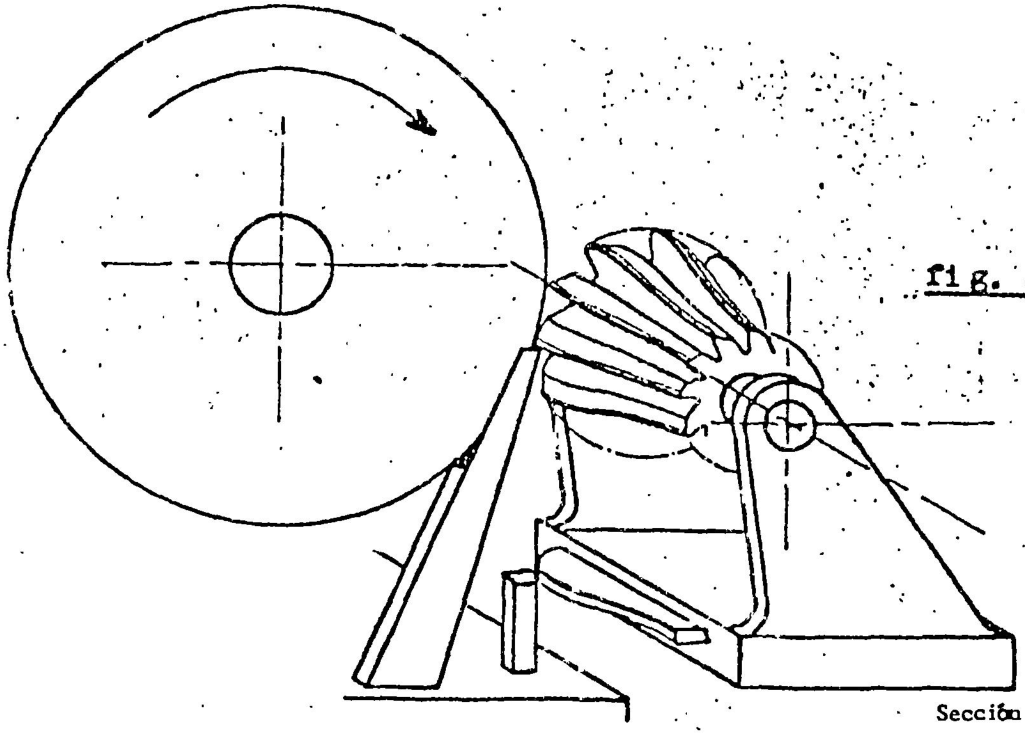


fig. 26

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DISEÑO DE HERRAMENTAL

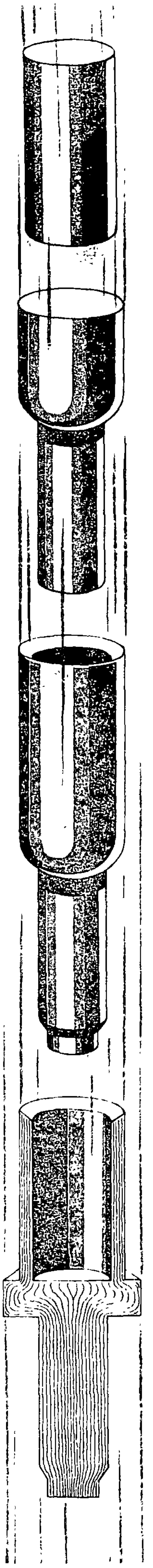
FORJA EN FRIO

ING. ULRICH SCHARER SAUBERLI

JUNIO, 1978.

FORJA

EN FRIO



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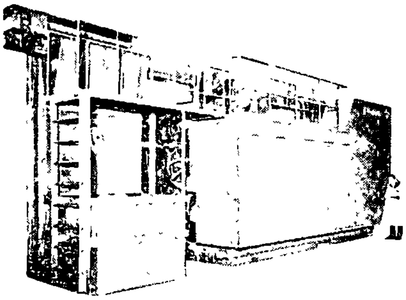
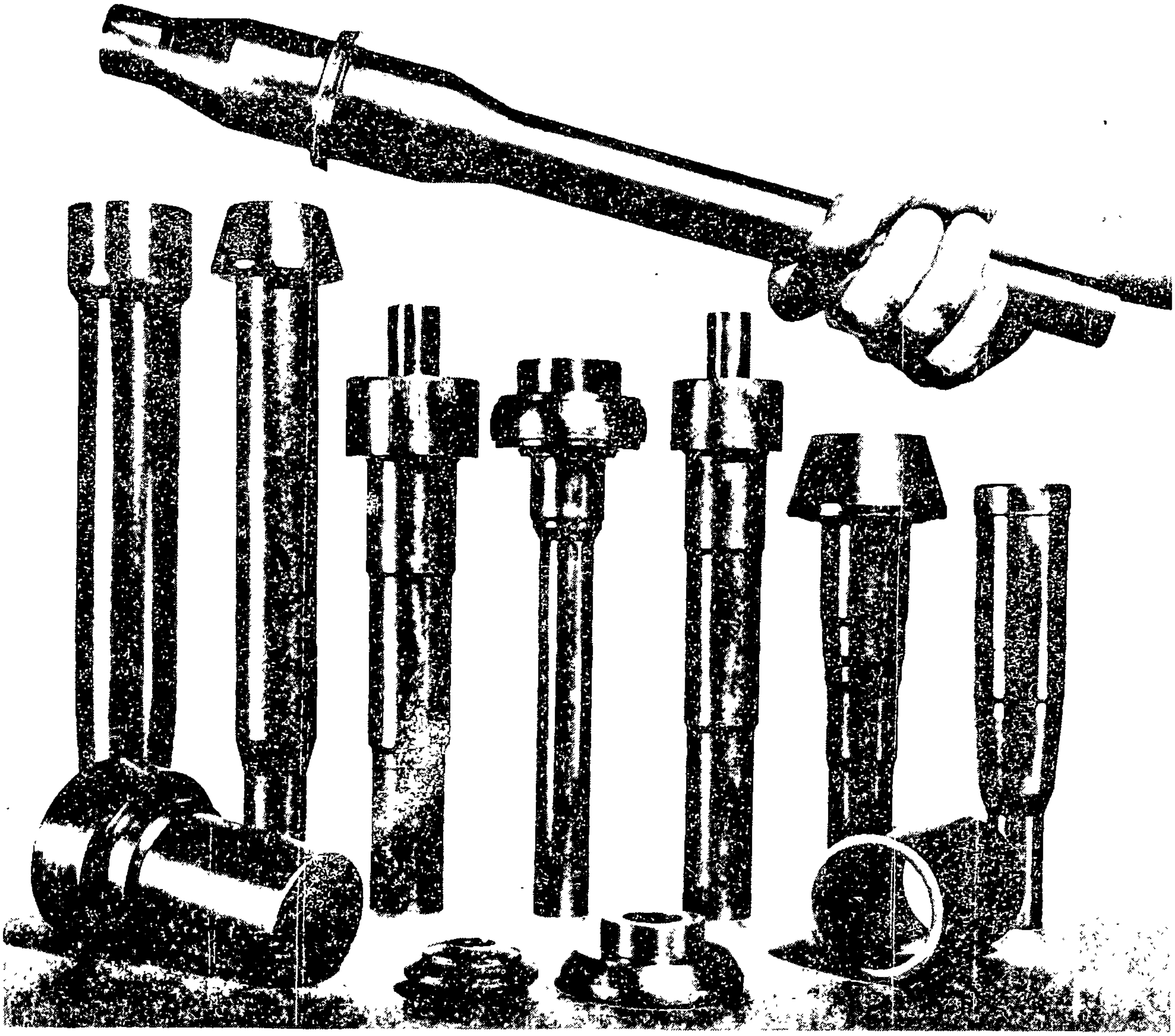
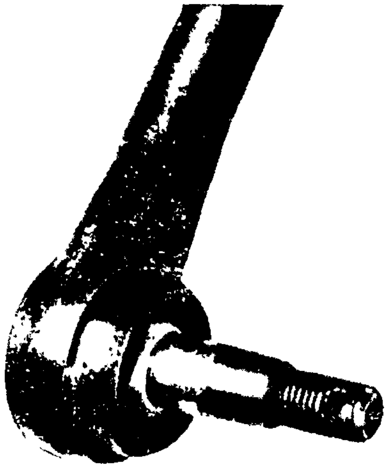
FORJA EN FRIO



Cold form seven tons per hour–automatically.





BALL STUD IS

FORGED STEEL

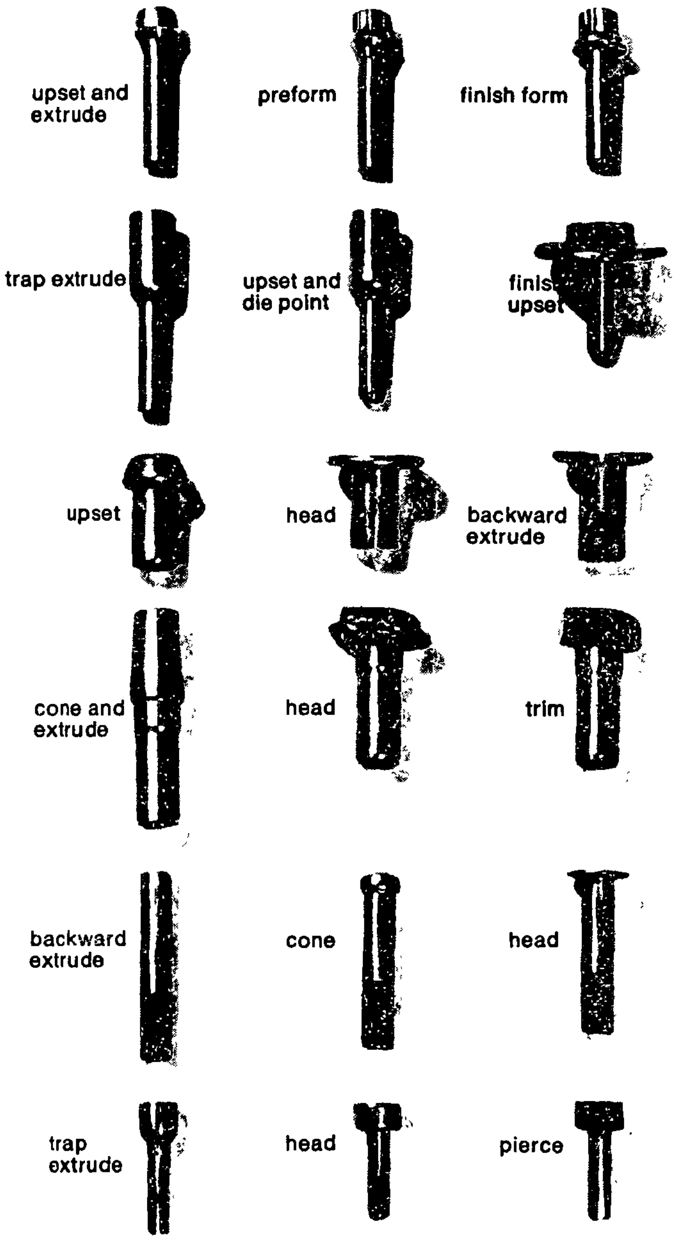
...and forged hollow!

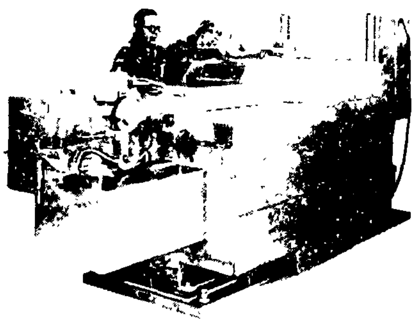
This hollow-ball stud has the strength and reliability so crucial to every part in automobile steering linkage systems. The stud is encapsulated in a plastic bearing material and assembled into the tie rod socket. Socket assemblies are available in both the extended and permanently lubricated designs.

TRW Michigan Division produces these unique studs from Bethlehem 1019 carbon and 8115 alloy steels. The steel is received in 1600-lb coils of .640-in. round bars, is drawn to size, and then upset-forged cold into the hollow-ball shape. The ball is skived and roll burnished to improve sphericity. Threads are roll formed and the cotter pin hole drilled prior to heat treating of the stud.

Upset forging is one sure way to improve product yield, but die design is crucial—and so is the integrity of the steel bar stock. Bethlehem steels are consistent in quality, right on spec in analysis, structure, properties, surface, dimensions. Ask your forger. He knows.

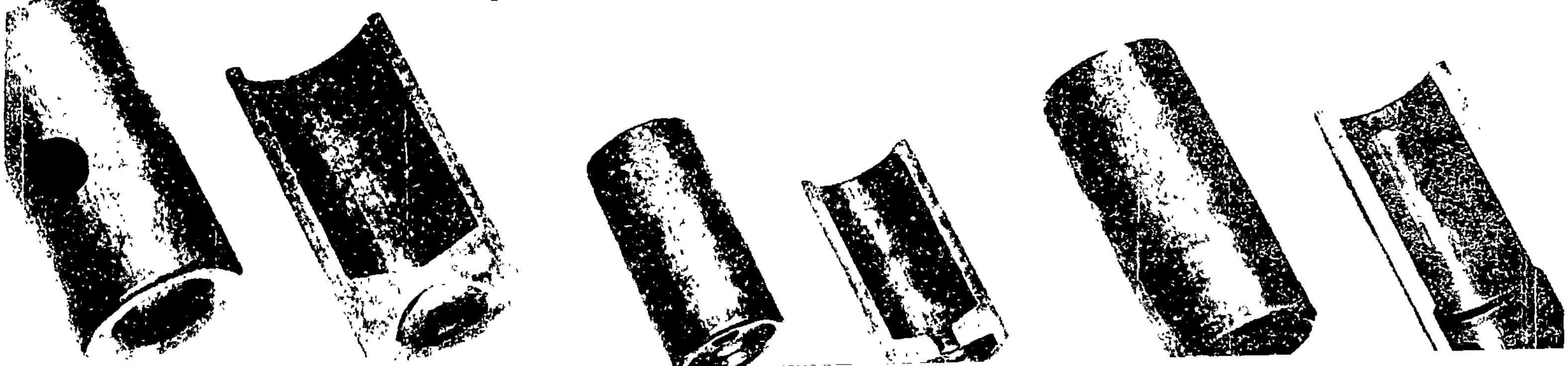
Simple as 1.......2.......3



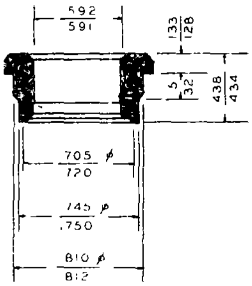


Complete and ready to use, these parts are made start-to-finish on National Headers, at unbelievably high speeds with excellent die life, in most cases with no loss of material.

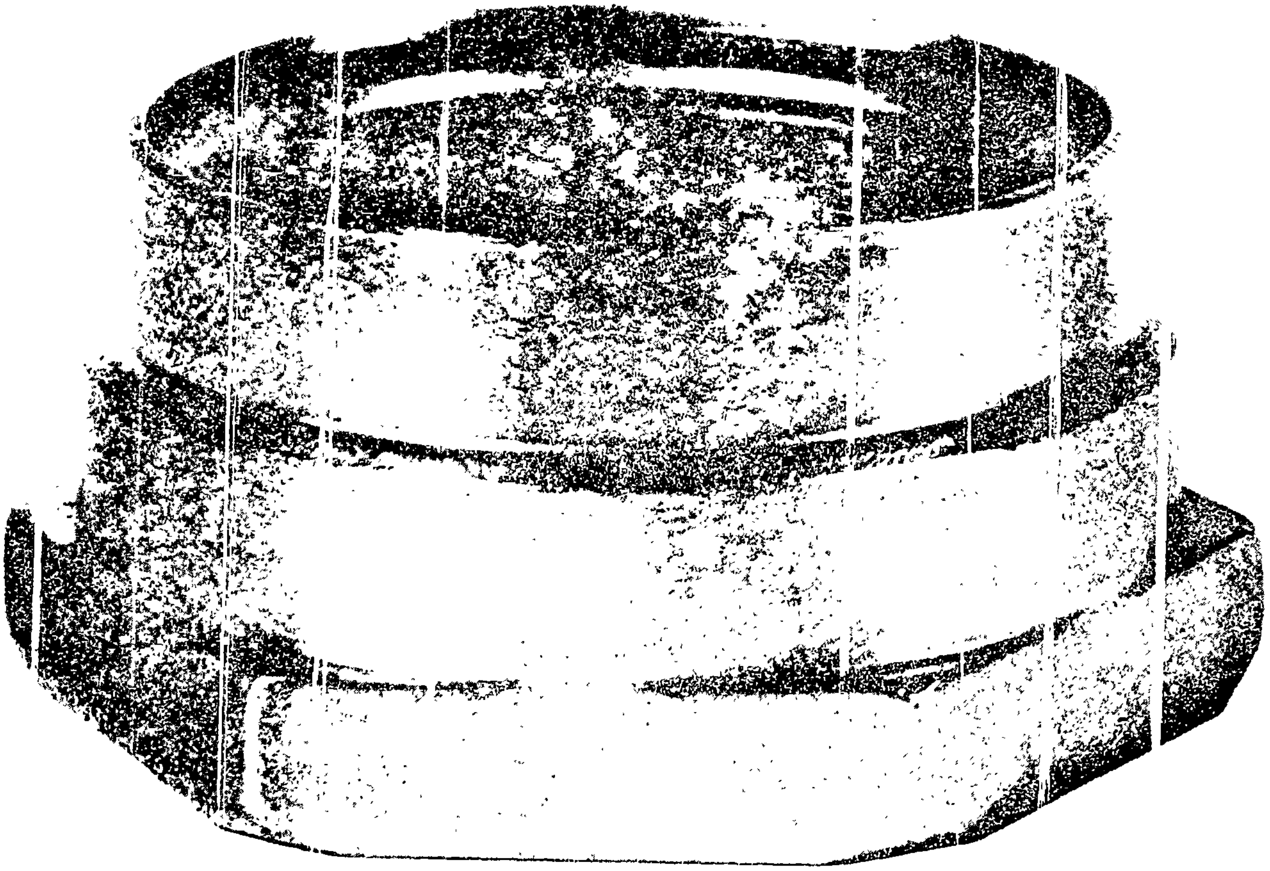
These deep extrusions were developed recently for production on National Cold Formers.

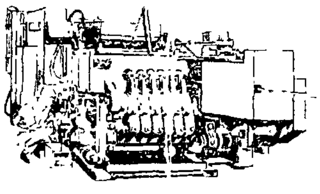


Cold forming delivers twice as many parts from same raw material.

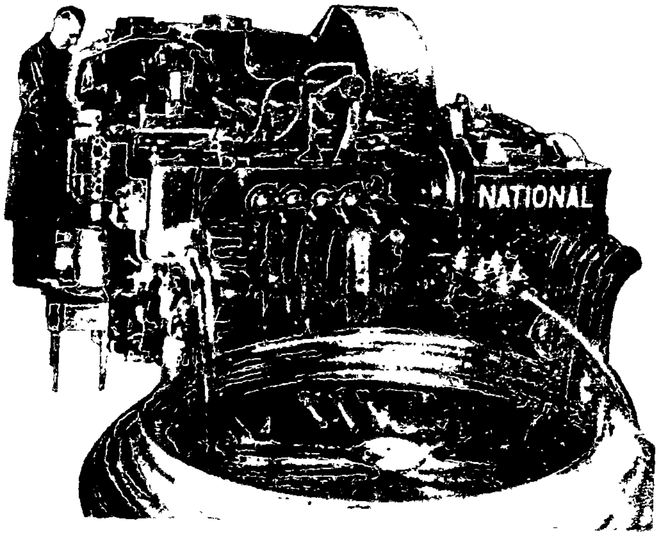


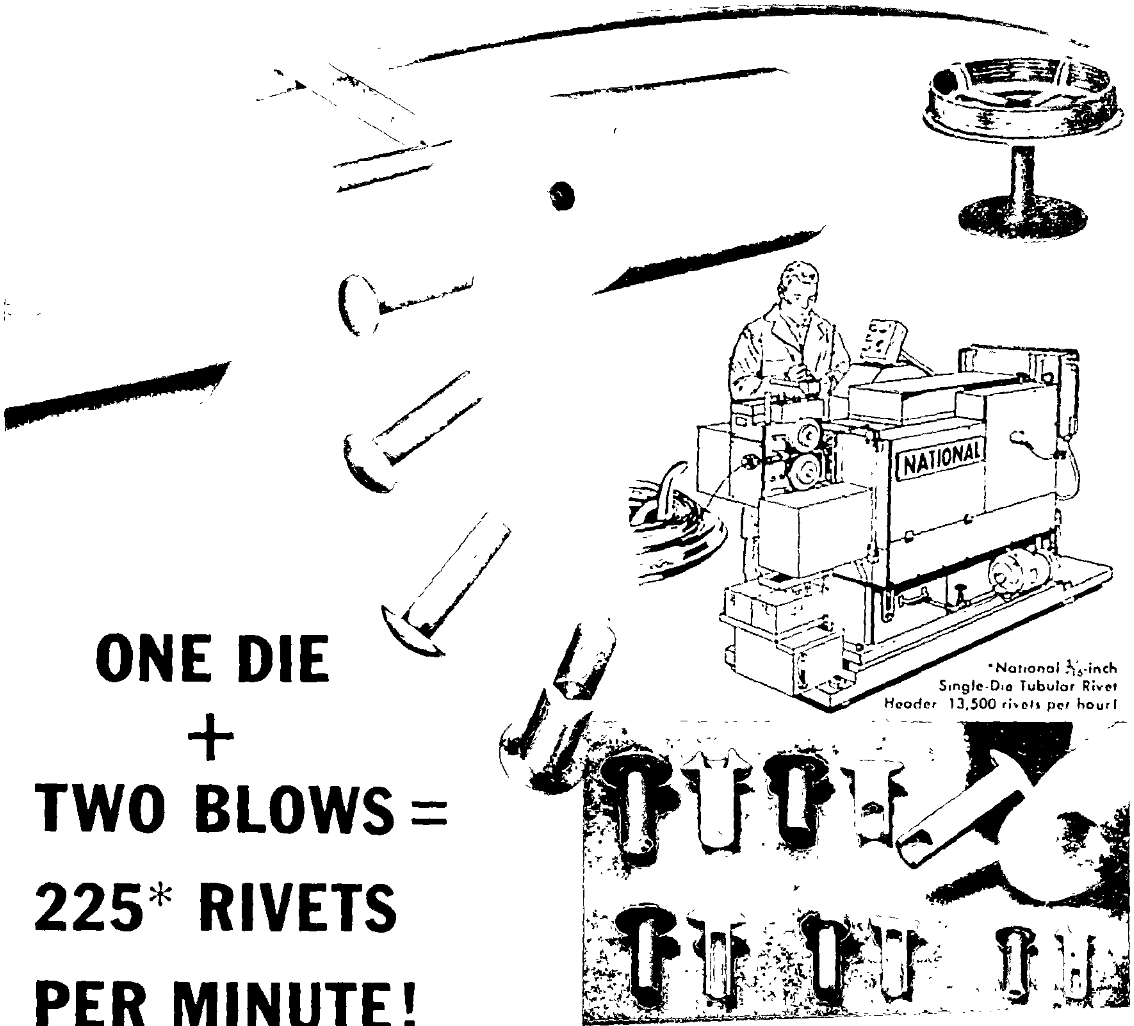
Part—Casting insert
Process—Cold forming
Production—50/minute
Material—AISI 1018





It looks like a nut, but it's a steel insert for a zinc casting. Shoulder diameter and overall length are formed to within .004" for compatibility with assembly and casting. Cold forming now easily meets quantity requirements and delivers twice as many parts from the same amount of raw material. An extra savings—coiled wire costs only ⅓ that of hex bar stock for screw machining. If you can save money on material and production, let us help you.





ONE DIE
+
TWO BLOWS =
225* RIVETS
PER MINUTE!

*National 3/16-inch
Single-Die Tubular Rivet
Header 13,500 rivets per hour!

How Renault Uses Cold Forming

Here's how a major automotive manufacturer has improved product quality while substantially reducing labor and material costs by switching from machining to cold forming

HORST WILMS
P & E Division, Klockner Inc.

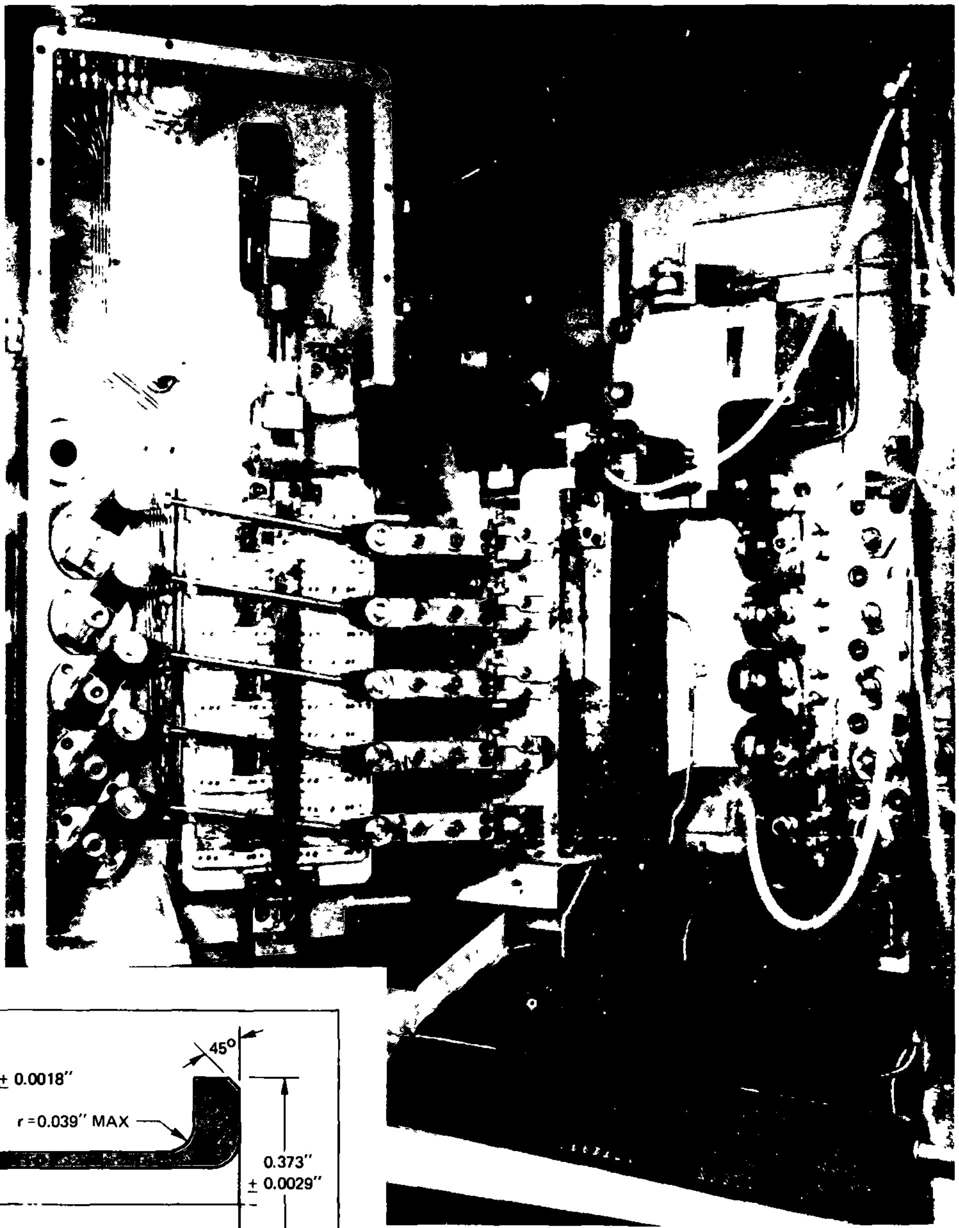
RENAULT OF FRANCE uses large quantities of a small flanged copper tube, *Figure* 1, in assembling hydraulic brake lines to automobiles. The tubes are inserted into the ends of flexible brake hoses at clamping points to prevent collapse of the hose due to clamping pressure.

The company has been producing these tubes for some time on automatic screw machines at a rate of about 12 per minute from each machine. Now they are cold forming the part on a five-station header at 72 pieces per minute using only about one-eighth the amount of copper previously needed. Substantial savings in labor and floor space requirements are also realized, and the formed parts have superior physical properties due to cold working.

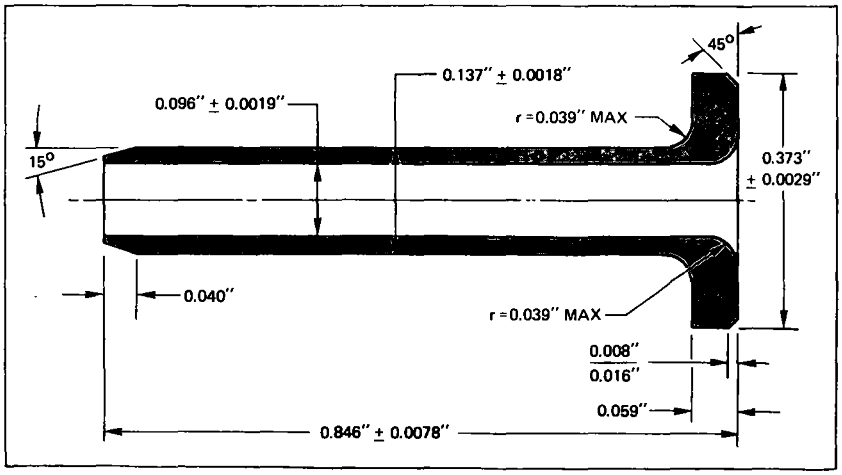
When produced on screw machines, the parts had to be made from bar stock since tubing with the required or smaller ID and an OD equal to or larger than the flange diameter was not available. More than 80 percent of the original stock had to be machined away to produce the required shape.

With the new production method, parts are cold formed from wire on a Boltmaster transfer header, *Figure* 2, made by Peltzer & Ehlers of Krefeld, West Germany. Material waste is reduced to about three percent, resulting in substantial cost savings. Tools on this machine are arranged vertically (one above the other) at the front, which permits fast and easy changing.

Problems Encountered. The change to cold forming wasn't as simple as it sounds.

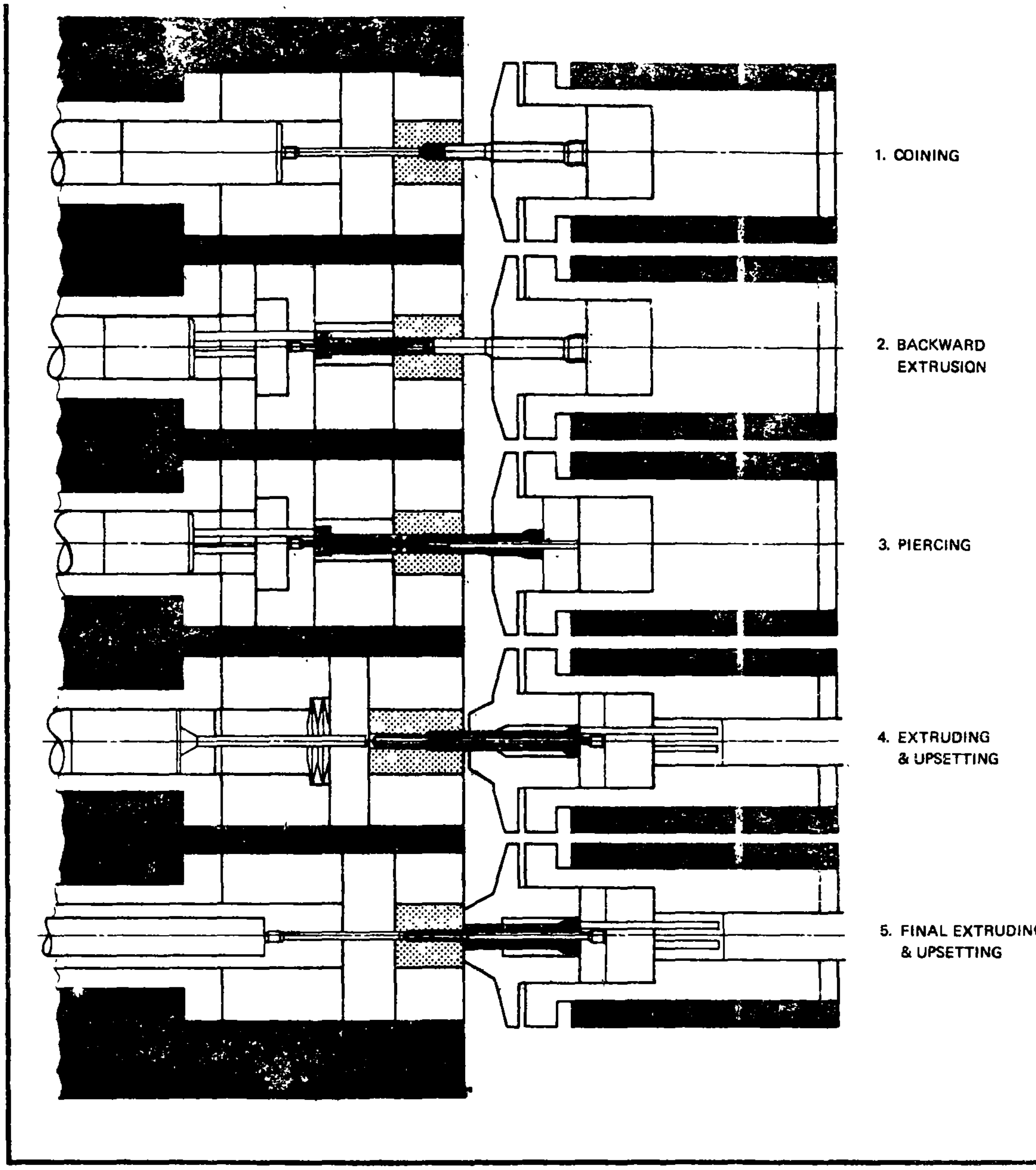


2. BOLTMASTER transfer header has tools arranged vertically at fro' 'f machine for fast and easy chan



1. FLANGED COPPER TUBE used in assembling hydraulic brake lines to automobiles is now being cold formed using only one-eighth the copper previously needed

3. SUCCESSIVE OPERATIONS performed on five-station cold header in producing part shown in Figure 1. Pins on ends of punches at Station 4 and 5 prevent collapse of shank.



Since the parts are assembled to brake lines by automatic machines, tight tolerances must be maintained. Also, the small size and complex shape of the part required special attention to tooling and material volume control, especially since no secondary operations are performed after cold forming.

In many cold forming applications, a trimming or pointing operation follows forming, either as the final step in the header or as a secondary operation. In such cases the forming tooling can be designed to flow excess material from the slug into that portion of the part which will be trimmed or machined away. This permits a more liberal variation in slug volume.

Since these tubes receive no final trimming or secondary operation, tight control must be maintained on the volume and weight of slugs entering the forming tools to assure fully filled parts without excess material. The only area in which excess material can be accumulated and then removed is in the web of the center hole, which is pierced out in the third station of the header. Minor deviations in the amount of material in the billet can be absorbed by forming and piercing a thinner or thicker web. This ability of the web thickness to accommodate slug weight differences is severely limited, however, and the maximum permissible variation in cutoff slug weight is only 0.01 gram.

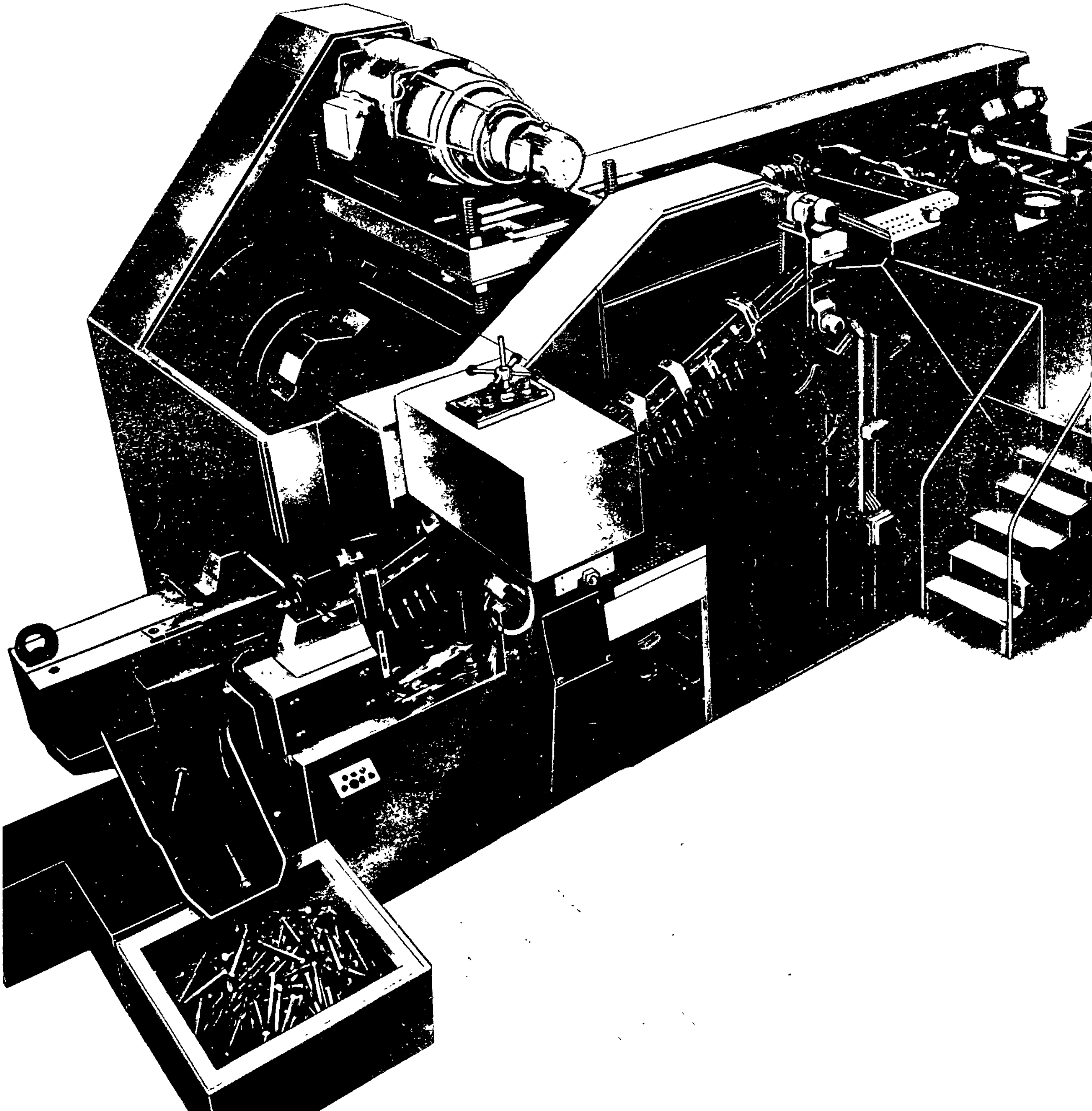
Processing Details. Raw material used is 99.9 percent pure electrolytic copper wire that is annealed, pickled and drawn prior to forming. Physical characteristics of the relatively soft material necessitate special provisions to achieve tight slug weight tolerances.

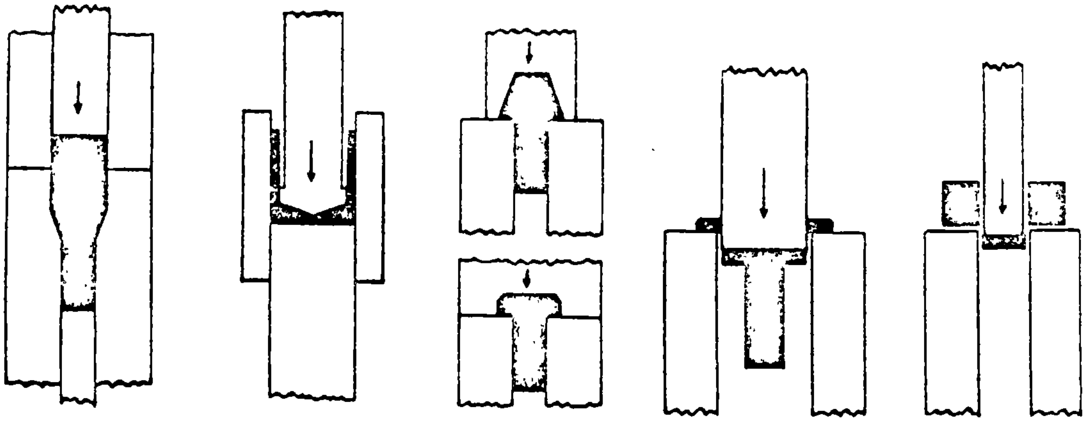
A set of feed rolls pulls the wire through straightening rolls and feeds it to the header. On each stroke of the machine, the end of the wire is advanced through a cutoff bushing until it contacts an adjustable stop set to produce required length slugs. A cutoff knife then shears a slug, which is gripped by the transfer mechanism and moved to the first forming station.

To make certain that slugs are never und[illegible], feed rolls are adjusted to hold the wire end firmly against the stop during shearing. When forming steel, little difficulty is experienced in maintaining slug length tolerance since feed roll pressure can be adjusted to grip the wire firmly enough to eliminate the possibility of slipping, and without danger of deforming the material. Also, because of the high modulus of elasticity of steel, longitudinal deformation caused by stress developed in the wire from feed rolls pushing it against the stop is insufficient to cause appreciable springback.

When forming copper or aluminum, however, this overstroke effect is not as easy to control. The wire cannot be gripped as firmly because of possible deformation. Additionally, the lower modulus of elasticity of these materials results in a greater degree of deformation during feeding, thus increasing the tendency for springback. For the tight slug weight tolerance required in this application, a special no-reverse, cam driven, positive feed roll drive mechanism was developed. This unit eliminates slack in the drive system, and prevents slip and backlash of the feed rolls to counteract springback of the wire just prior to cutoff. It permits holding the weight of slugs between 1.8552 and 1.8653 grams.

Operations performed at each of five stations on the header are shown in *Figure* 3. At the first station, coining dimples both ends of the slug, rounds one end, and increases the slug OD by about three percent. Backward extrusion to form the center hole is performed at the second station, and the web in the bore is pierced at the third station. At Station 4, the shank is extruded and the head upset. Final extrusion of the shank (including forming the required taper on the outer end) plus final upsetting of the flanged head and forming of radii are done at the fifth station. Pins in the ends of the punches at Stations 4 and 5 enter the workpieces to maintain bore size and prevent collapse of the shank during extrusion and heading. ◀





Vorwarts-Fließpressen

Rückwarts-Fließpressen

Kopfstauchen

Abgraten

Lochen

Bild 29 Beim Kaltumformen werden fünf Grundarbeitsgänge ausgeführt
Verschiedene Kombinationen und Variationen dieser Arbeitsgänge geben dem Kaltumformer ein breites Anwendungsgebiet

$$P = p \cdot F_0 = P_{st} (F_0 - F_1) = P_{st} \cdot F_{st}$$

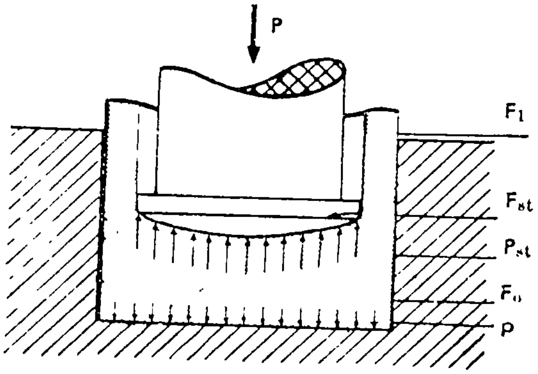


Bild 28 Belastung von Stempel und Matrize beim Rückwärts-Napffließpressen

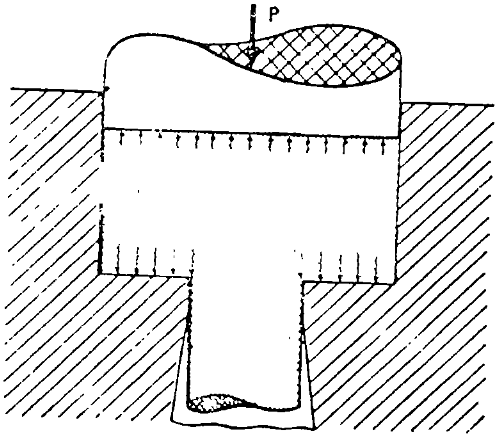


Bild 29 Belastung von Stempel und Matrize beim Vorwärts-Vollfließpressen

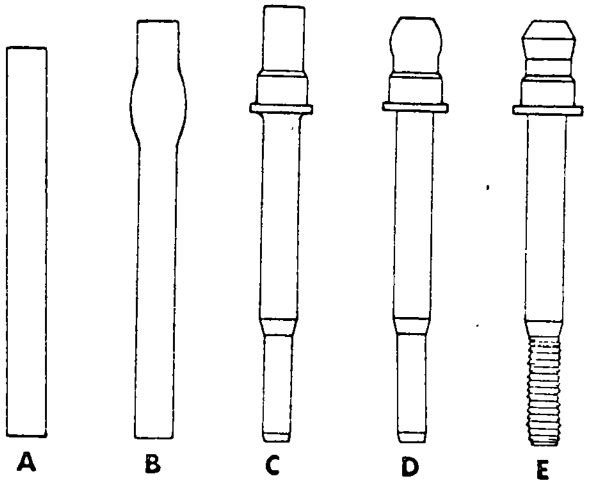


Bild 5 Zundkerzen-Mittelstabe ohne Materialabfall kaltgeformt und gewalzt
Eine Maschine produzierte fast zwei fertige Teile/Sekunde

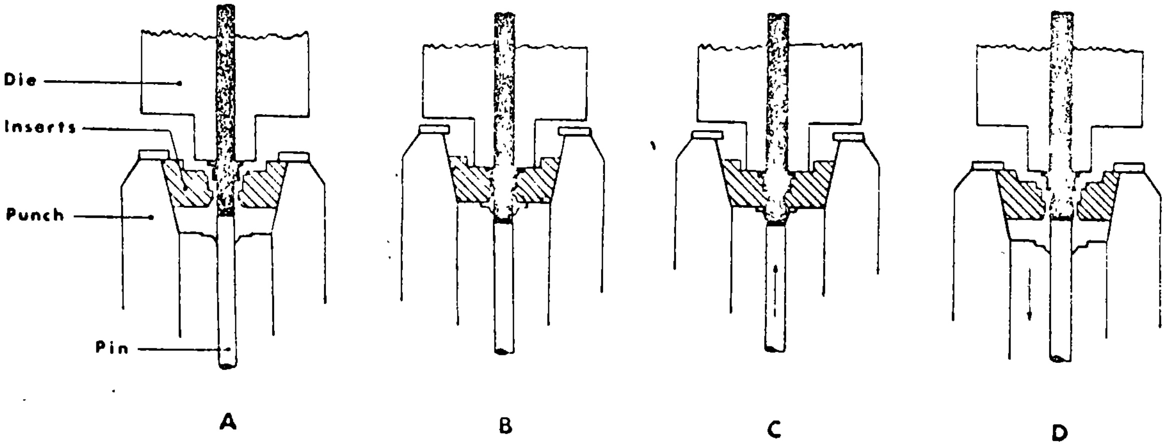


Bild 6 Durch besondere Werkzeugauslegung auf der Stempelseite wurde Stauchung des Mittelstabes ermöglicht;
vorher war diese Form nur durch spanabhebende Bearbeitung zu erreichen
Die = Matrize, Inserts = Einsätze, Punch = Stempel; Pin = Stift

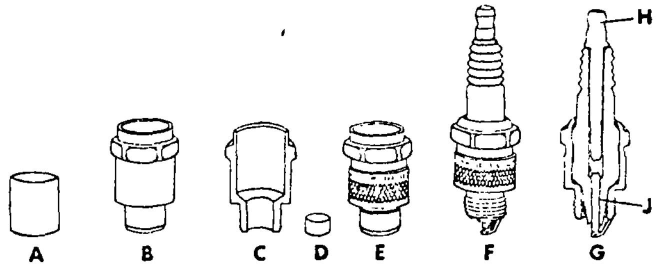


Bild 2 Verschiedene Fertigungsstufen bei der Produktion von Zündkerzen

(A) Der vom Drahtbund abgeschnittene Rohling – das Ausgangsmaterial für den kaltgeformten Körper (B und C)

(D) Materialabfall nur 6 % des Rohlinges (A)

(E) Der nachbearbeitete Zündkerzenkörper

(F) Die fertige Zündkerze

(G) Querschnitt durch die fertige Zündkerze, mit Mittelstab und Elektrode (H und J)

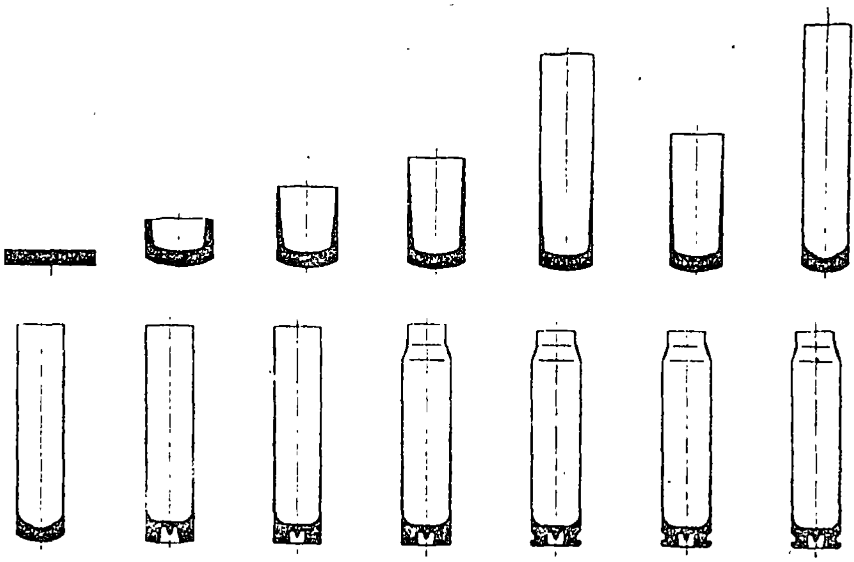
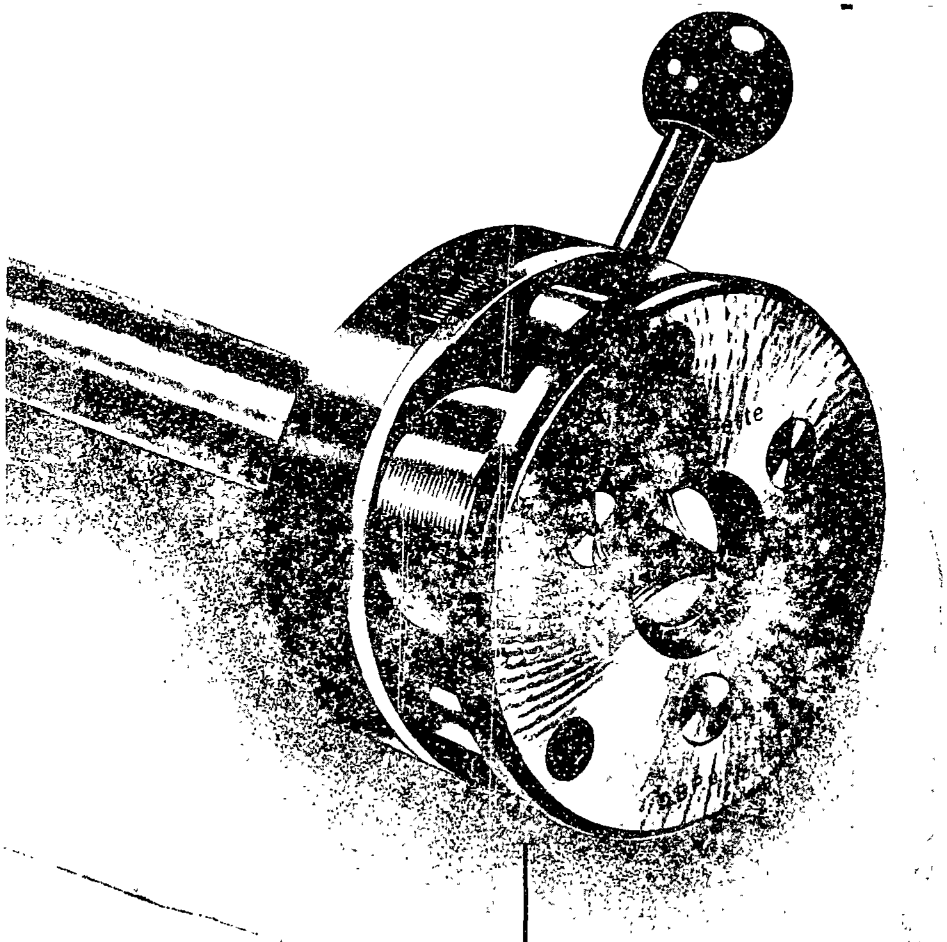


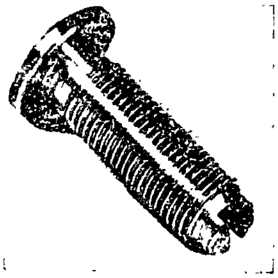
Bild 22 Arbeitsfolge der Patronenhülsen



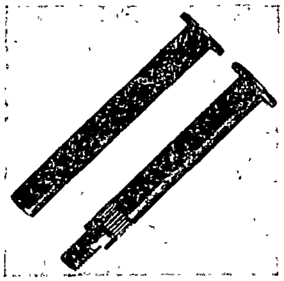
Einige Zeitbeispiele

M 12
Länge 23 mm in 0,5 sec

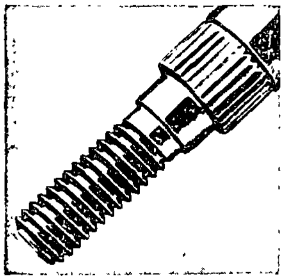
M 8 × 1
Länge 15 mm in 0,6 sec



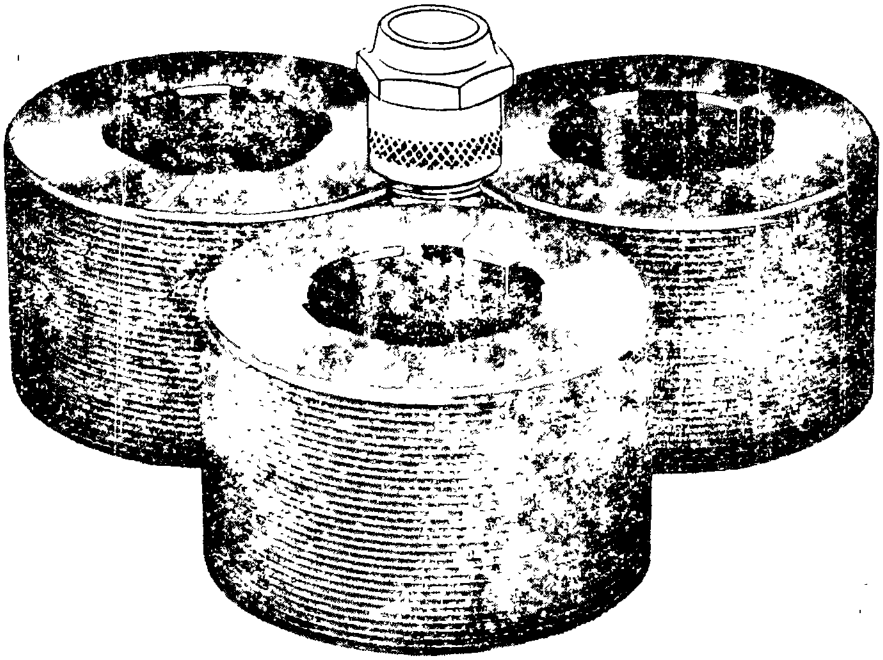
M 10 × 1
Länge 20 mm in 0,6 sec



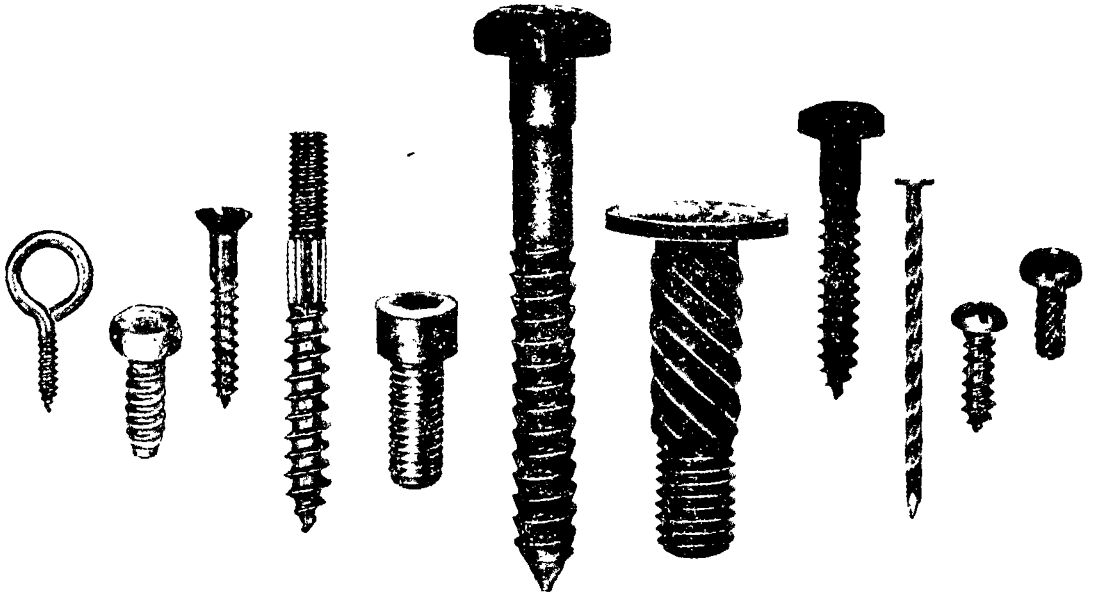
M 5
Länge 8 mm in 0,27 sec



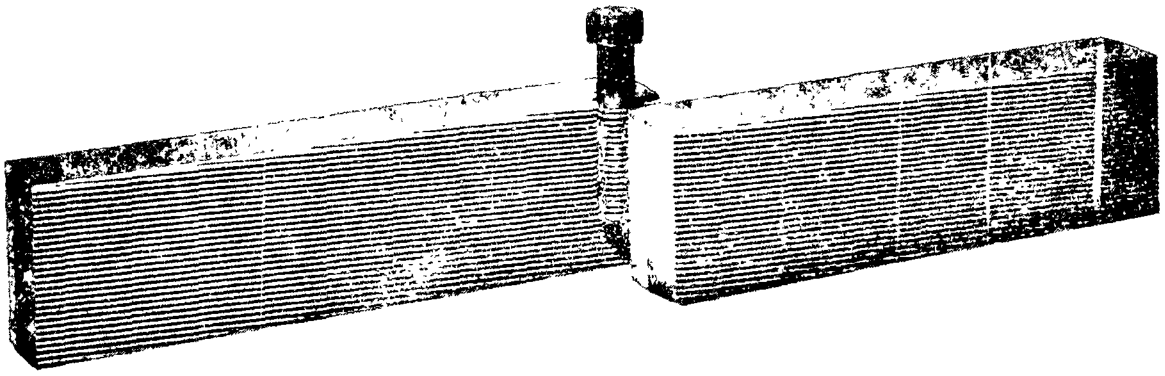
In einem Arbeitsgang:
M 6 Länge 30 mm
Rändel 8,5 mm ∅,
0,8 mm Teilung,
Länge 10 mm in 0,7 sec



More can be done
with Reed Cylindrical Dies



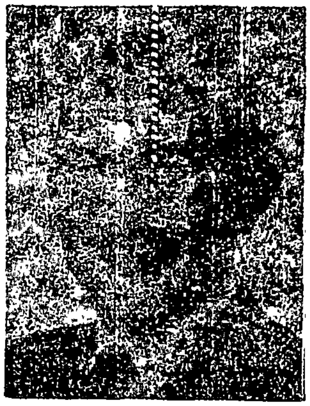
More Can Be Done



With Reed Flat Dies!

MATERIAL FORMING

TECHNICAL PAPER



ENGINEERING CONFERENCES

Designing for Cold Forming and Extrusion

by

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For presentation at its
Engineering Conferences

LITHO EN MEXICO

Designing for Cold Forming and Extrusion

Al Braun
Braun Engineering Co.

IN ORDER to have a good basic approach in designing for cold forming and extrusion, it is best to discuss the subject of what it is, its history, how it is done, and its economics; before covering the design possibilities and limitations. This way, an idea can be formed not only of what the design possibilities and limitations are, but why it is so.

Cold forming covers many types of shaping metals cold, and as most of these are familiar, I will not cover in this paper such methods as: sheet metal, blanking, bending, drawing, up-setting on a cold header, rolling of threads, swaging, coining, and spinning. These methods have been used for many years, and even though the processes today are being improved, the really new thing on the horizon is cold extrusion. This differs in the main from the other cold forming methods mentioned in one respect, and I think Webster's definition illustrates it clearly. The dictionary states that to extrude is (1) to force, press, or push out, and (2) to shape by forcing through dies by pressure. There is a real difference. In the conventional cold forming techniques, the work piece is wrapped around the tools or pushed by the tools with a minimum of sliding action plus heavy pressure between the work piece and the tools. Cold extrusion, on the other hand, requires considerable sliding of the metal of the work piece against the tools under extremely heavy pressure. This is why extrusion is so troublesome.

I doubt that many think of the star shaped metal disc on the front of a housewife's cake decorating gun as an extrusion die. It is, however, and in the truest sense of the word, for as she squirts out the whipped cream or icing, she is extruding exactly the same way in which we extrude steel except that we use a few tons more pressure This is called forward extrusion. The substance being extruded travels in the same direction as the plunger or extrusion punch.

Every time you step into a mud puddle you are making a backward extrusion. To illustrate the point more clearly, imagine filling a pail full of damp clay. As you step into it, the clay will rise above the rim of the pail forming a tube. The clay tube would have an outside diameter equal to the inside diameter of the pail. The inside of the tube would be the shape of your foot. This is called a backward extrusion. The substance being extruded travels in the opposite direction as the plunger or extrusion punch.

Product designers, however, seldom make things so easy for us that a simple forward or backward extrusion can be used. Usually the parts we manufacture are combinations of one or more of the following: backward extrusion, forward extrusion, ironing, coining, nosing, and/or upsetting.

Fig. 1 is a schematic illustration outlining the different methods of cold extrusion and closely allied methods of cold forming.

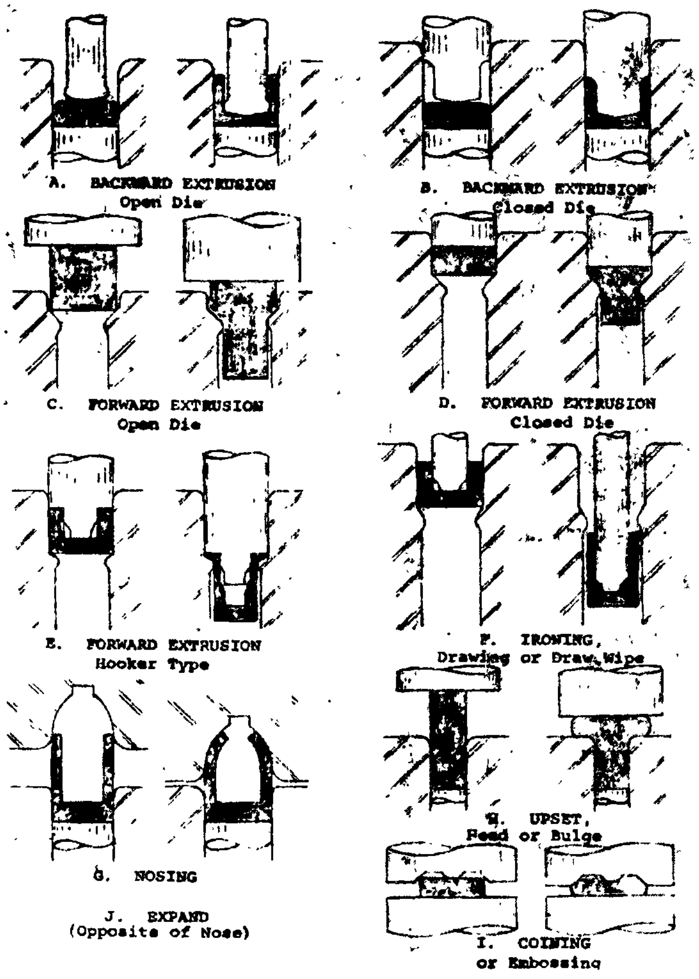
HISTORY

The first cold extrusion of metals was done in our country about the turn of the century. By an ingenious mechanism, lead was forced through an opening on to a cable passing through the die giving us lead sheathed cable. In the 1920's, tin was cold extruded into tubes for oil paints, toothpaste, and the like. In the early 1930's, toothpaste tubes were extruded from aluminum.

Very light cold extrusion of steel has been done here and abroad for many years in such industries as the cold heading

ABSTRACT

Cold extrusion - what it is, its history, how it is done, its economics, and its design possibilities and limitations - is the subject of this paper. Forward and backward extrusion are discussed as well as the steps taken towards the production of small extrusions. Screw machines, seamless tubing, forging, casting, and stamping are all considered both in their separate functions and with regard to their advantages and disadvantages. The appendix illustrates desirable and/or undesirable features of many possible types and combinations of extrusions.



A. BACKWARD EXTRUSION Open Die
B. BACKWARD EXTRUSION Closed Die
C. FORWARD EXTRUSION Open Die
D. FORWARD EXTRUSION Closed Die
E. FORWARD EXTRUSION Hooker Type
F. IRONING, Drawing or Draw Wipe
G. NOSING
H. UPSET, Head or Bulge
I. COINING or Embossing
J. EXPAND (Opposite of Nose)

Fig. 1

industry where the extrusion of a thread pitch diameter from its nominal body diameter has been a standard practice for many years, but this was always very limited in terms of reduction of area.

During World War II the Germans, being short of steel and alloys, used the present phosphate coatings that make the heavy extrusion of steel possible. They produced shells not only by cold extrusion (thereby saving great quantities of steel) but also, in their use of the work hardening characteristics of cold extrusion they were able to lower the alloy content of the steel used without lowering the physicals of the end product.

After the war was over, the United States started to produce shells by using the German processes, presses, and engineers. It was at this point that our company learned of this process and saw the tremendous potential of cold extruding peace time goods. We could see extruding not only the big 3 or 4 in. diameter parts but by using automation, extruding smaller parts that sell for a few cents. Creating a cheap, good slug was one of the big problems. We started by blanking out round slugs from plate stock. This was expensive as we still had quite a bit of waste in the skeleton, and labor and material handling costs were high. Above all, tolerances on plate being what they were, we could never be sure of the volume of material in the slug.

Cold heading seemed the proper approach to overcome these difficulties. When we overcame the problems of cold heading the slug, the high production of low cost extrusions was made possible and is the method generally in use today.

HOW IT'S DONE

On small extrusions the steps are usually as follows:
1. Head slug.
2. Degrease.
3. Anneal.
4. Bonderize.
5. Extrude.
6. Secondary operations.

On larger extrusions, step 1 differs in that hot rolled bars are either sheared or sawed and preformed. The other steps are the same.

Head Slug - In our operation we bring in hot rolled rods in large coils. These are pickled and lubricated in the conventional manner. The rods are cold drawn on Ajax-Houge wire drawers attached to the cold header. The slug is then headed at rates of 160-180/minute.

Extreme caution and rigid inspection must be maintained at this point. It is impossible to make a concentric extrusion from an eccentric blank. The weight of the slug is watched very closely, especially on slugs which will be extruded in a totally confined extrusion die. In these instances the effects of an oversize slug on the tools and cranks of presses is devastating. It is often more difficult to produce a good slug than to produce a good extrusion. In order to maintain size control in the extrusion operation, we find it necessary to load the yield in slugs from each coil of the rod in separate containers and hold them separate from this operation through the extrusion operation.

The reason for this is the inconsistency of raw material. We usually use a rimmed steel for cold heading slugs because the surface is so much more free of seams. Now from the top of the first ingot poured to the bottom of the last, there is a drastic difference in composition. As a matter of fact, from one coil to the next there is only one thing that you can be sure of and that is that it's different. We sometimes refer to steel as fruit cake. Sometimes you get more fruit and sometimes you get more nuts.

The deflection of any press is now in proportion to the resistance of the load. If in the relation of punch to die, you put in a harder slug one time and a softer slug the next, the bottom thickness of your part will consequently vary in direct proportion. It is better to have uniformly bad material than to have some good and some bad. At least you can adjust your press to hold tolerances on what few parts you get before the punch breaks.

For producing a somewhat larger slug beyond the capacity of cold heading equipment available to you, shear and upset is used. The shearing of, say, a 2 in. diameter bar usually produces a rather distorted blank depending on length sheared, so that an upset is used to square up the blank. This, by the way, is an excellent check on the raw material. Any surface seams present in the steel open up very satisfactorily for visual inspection.

When you go into larger parts where shear and upset cannot reasonably be used, high speed saws followed by a deburring operation are generally used. Again, care must be taken that the cut is square and the proper weight of blank is maintained.

In conclusion, the three most used methods of producing slugs in order of cheapness and size range are: cold head, shear and upset, and saw.

Other methods for special applications can be used such as banking for thin, large diameter slugs, sawed tubing or welded rings for ring slugs, and casting of aluminum slugs, but in the main the aforementioned three methods are currently most popular.

Degrease - Conventional degreasing equipment is used. The main purpose of this operation is to get oils and greases off the slugs before heat treating. The residuals of these oils and greases could be baked into the surface of the slug so hard that they would be very difficult to remove before bonderizing.

Anneal - There are two reasons for annealing. The first reason is that with the handling of the slug so much cold work has been performed that further working is impractical. The other reason is that the softer the slug the better the tool life on extrusion tools, which is why we feel the best anneal possible is the cheapest. We use a Lee Wilson bell type furnace, such as is commonly used in steel mills for annealing strip and wire.

We use a long cycle not only for softness but for uniformity. Again I want to stress that uniformity of Rockwell is absolutely important in order to hold dimensions properly in the extrusion operation.

Bonderizing - Our bonderizing installation contains 17 tanks in a row, but many of them are duplications and alternates. The stainless steel barrel actually goes into only nine of these tanks, as follows:

1. Alkali clean.
2. Hot water rinse.
3. Sulfuric acid pickle.
4. Cold water rinse.
5. Hot water rinse.
6. Bonderize.
7. Cold water rinse.
8. Neutralize.
9. Bonderlube.

The lead off tanks are all for getting the slugs chemically clean to get a good zinc phosphate coating in tank No. 6. This coating is an acid operation depositing zinc phosphate crystals on the work as well as etching itself into the surface of the slugs. These zinc phosphate crystals are not a lubricant in themselves, but serve as the separating layer between the work piece and the dies and also as a honeycomb into which the soap from the last soap tank dip embeds itself. If the soap dip were tried without the honeycomb of zinc phosphate crystals, the pressures at which we work would upon contact immediately dispel the soap from between the tools and the work, and there would be no lubricant with which to carry on the extrusion operation.

The other important tanks are the soap tanks. We have three different ones, because we feel there is no one soap made, which is ideal for all work. Consequently, we vary the soap lubricant to suit the particular application at hand.

Extrude - The presses we use are mainly mechanical, crank, or eccentric shaft types. We prefer mechanicals because they are faster. Hydraulics are better when a long work stroke is required. The main feature that differentiates our presses from an ordinary press shop is their rigidity; high tonnages with small bed areas.

The main thing to stress in dies is the same as for presses, namely rigidity. The steels we use in our punches and dies vary. There is no one steel best for every job. We actually use water hardening, oil hardening, and air hardening tool steels, high speed steels and tungsten carbide, all depending on the individual job on hand.

The subject of design and construction features of the extrusion tools is a vast one and not within the scope of this paper.

Secondary Operations - The economic success or failure of cold extrusion often hinges on the secondary operations left to be performed. In many instances the parts can be used as they come from the extrusion operation, in which case there are no problems.

If secondary press operations are required by the means of dials or other feeding mechanisms, these may well be done progressively on the same press. If this is done, extreme care must be exercised in locating the heavy extrusion operation in the press so that a lopsided thrust is not put on the extrusion tools due to press or die deflection.

Where secondary press operations are used to deform the extrusion further, doing them as soon as possible (within a few seconds) after the extrusion is often of great advantage. Work hardening seems to be a product of severity of work performed and time after work is done. Often a secondary draw, for instance, can be done successfully if done within a few seconds; whereas, if tried an hour later the metal will rupture.

In higher carbon or alloy steels a subcritical anneal between operations may become necessary. In these events a rebonderizing is also necessary.

The design variations that are possible by using more then one severe cold working operation are infinite, limited only by economics, showing that it may be cheaper to do it some other way.

Secondary turning is one of the most commonly required additional operations. There is, to our knowledge, no multiple spindle standard equipment built for small parts, but I feel sure that as cold extrusion gains in popularity the machine tool manufacturers will recognize this need and remedy the situation. For the present, standard bar machines are converted by adding hopper feeds, or magazine feeds and chutes to convert them to an automatic chucking operation. Internal chucking seems to be the most common, leaving one end and the entire OD open for turning, threading, drilling, and so forth.

By its hardening effects cold extrusion converts even such material as 1010 steel into a fairly good machinable item.

In spite of the high deformations used in cold extrusions, the parts can still be readily thread rolled.

If stresses are applied in a different direction than the original extrusion stresses, the parts can still be further cold worked even months later, such as in crimping over a switch housing or spark plug.

ECONOMICS

It must be remembered that cold extrusion, like any other process, is not a cureall. It is only one other method of manufacture in competition with existing efficient methods. To go further into cold extrusions advantages and disadvantages we must compare it with individual processes such as: screw machine, seamless tubing, forging, casting, and stamping.

Screw Machine - A screw machine is a very efficient piece of machinery. One man can operate two to four of them and usually a finished part drops off. Its main disadvantages are that it is slow in comparison with a press operation and that it uses too much steel.

Let's take a typical stoplight switch housing for example. The screw machine uses 404 lb per thousand parts. We use 65 lb per thousand parts which means a savings of 84%. Theirs must be an ARR special quality cold drawn hex bar while ours is a hot rolled heading quality rod. But here our advantage ends. All they do is put it on the screw machine and make parts whereas we must:

1. Pickle and lubricate wire.
2. Draw wire and upset slug.
3. Degrease.
4. Anneal.
5. Bonderize.
6. Moly coat.
7. Extrude.
8. Tread roll.
9. Turn and drill.

We have, then, nine operations instead of one. Fortunately, this is a very high production job and we can afford to automate to a high degree. Because the raw material advantage is so greatly in our favor and our individual operations are so cheap due to high quantity, we can easily offset the eight additional operations we require. Our selling price is about 30% lower than the screw machine price.

From the foregoing you can see that had we not been able to save so much material, or had the production been so low that we could not afford automation, the eight additional operations would have defeated us in the competition with the screw machine. Of course, when the screw machine also has secondary operations, competition becomes a little easier.

As parts get bigger, the unit metal saving grows larger and cold extrusion becomes more worthwhile. If cold extrusion produces a finished part, we also become more competitive. The motor mount is a good example of this. We are able to sell this part for approximately 20% less than the steel cost alone for the screw machine part.

Seamless Tubing - We can usually beat a piece of seamless steel tubing if:

1. One end is closed.
2. Changes in wall thickness are required, or taper wall.
3. Nonround shapes are required on either OD or ID.
4. Closer than standard tolerances are required.

Forgings - On a simple symmetrical one hit extrusion, the cost is nearly always cheaper than a forging disregarding the other obvious advantages of cold extrusion. When a number of hits is required to complete the extrusion or cold forging, the race becomes more competitive. Generally cold extrusion has the advantage of holding closer tolerances, using less steel, and thus requiring less machining.

Casting - As with the forging on simple one hit symmetrical extrusion the cost is nearly always cheaper than a casting. The additional advantages of cold extrusion are: lack of porosity, more strength per section, less weight required, closer tolerances and less machining.

Stampings - It is seldom that a cold extrusion can be produced cheaper than a stamping. The only cases that I can recall are where one cold extrusion can take the place of a stamping assembly or on exceptionally deep draws where one or more anneals are used between operations.

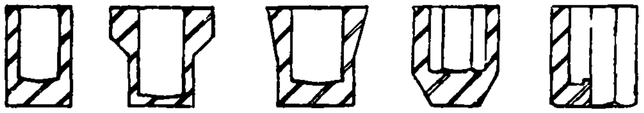
It is of interest to note that on larger deep cuts the tool cost of a cold extrusion can be a small fraction of the cost of a series of draw dies making cold extrusion economically sound on very small quantities of parts required.

So far, we have talked only about the advantages of cold extrusion. There are warnings necessary. At this stage of development it is more an art than a science. When we first started we often made more punches than pieces. Even now the tool upkeep is one of our greatest cost items. On many parts the tool upkeep labor is greater than the productive labor.

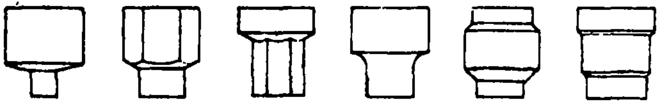
In order to make a first small cold extrusion on a competitive basis, it takes a minimum investment in capital equipment of $250,000. After this a set of tools is needed and then, of course, the research and development. As a rule it is far better for a company that has had no previous experience with cold extrusion to start by buying their parts from a reputable cold extruder. After both the feasability and economic advisability of a given cold extrusion have been proved, not from a sample run but from an extended production run, only then should the subject of capital equipment expenditures be considered.

To summarize: there are great savings to be made with cold extrusion on many parts. However, there are many improvements to be made in designs, tool steels, and lubricants.

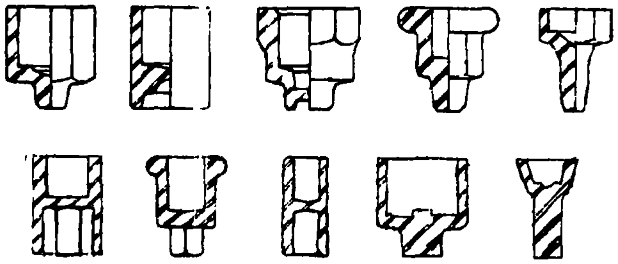
The design limitations of today are temporary. There are no experts in cold extrusion, only varying degrees of ignorance. And cold extrusion will never completely replace



One Hit Backward Extrusions Possible

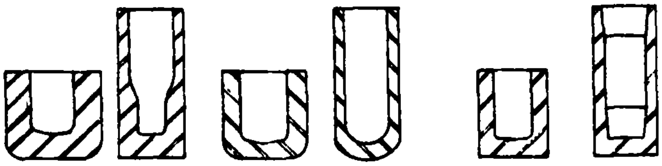


One Hit Forward Extrusions Possible

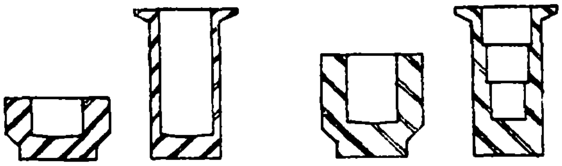


One Hit Combination Backward, Forward Extrusions Possible

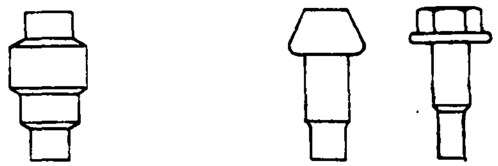
Fig. 2



Backward Extrude and Iron Possible



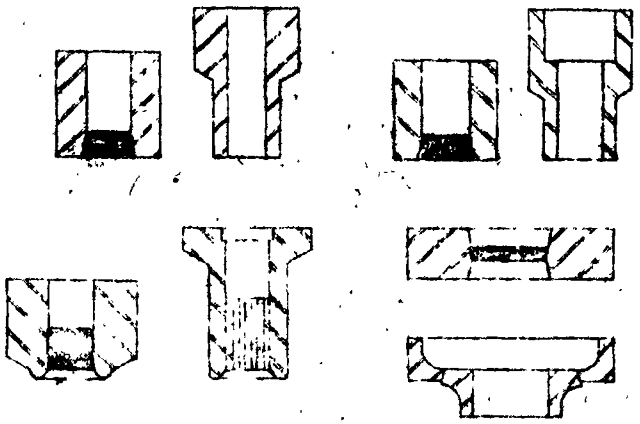
Backward Extrude and Forward Extrude Possible



Two Hit
Forward Extrude

Forward
Extrude and Upset

Fig. 3



Backward Extrude, Pierce, Forward Extrude

Fig. 4

any existing method of manufacture. It is only one more process or tool for the design engineer to work with.

Figs. 2-4 illustrate the many types of extrusions possible, especially when several types of extrusion or extrusion and other heavy metal working operations are used in combination. This is by no means a complete list but only a starter. With these rudiments of extrusion in mind, other combinations can be devised.

In backward extrusion the basic and easiest part is illustrated in Fig. 5.

Diameter A - A good commercial tolerance on mild steel for a 1 in. diameter would be 0.004 and for a 5 in. diameter 0.010. Closer tolerances can be held, but this causes excessive die wear and thus raises manufacturing costs.

Diameter B - A good commercial tolerance on mild steel for a 1 in. diameter would be 0.003 and for a 5 in. diameter 0.006. Again closer tolerances can be held, but costs of manufacturing are increased by excessive punch wear.

Diameters A and B - Concentricity on a 1 in. diameter part should be held to 0.008 and on a 5 in. diameter part 0.015.

Much closer tolerances can be held on any of the above three dimensions by following the backward extrusion with an ironing opeartion, but this of course is also expensive.

A simple classic extrusion as shown in the mild steel area of diameter B can be 90% of the area of diameter A(90% reduction of area).

Dimension C - This is a very difficult dimension to hold. The elements causing dimensional variation on this item are:

1. Volume or weight variation of the slug used to make this cup. Both diametric and cut off length variation affect this.
2. Press setting variation.
3. Hardness variation of the slug causing varying press deflection.
4. Die and punch wear (varying the volume of the finished part).

Tolerance required on a part with 75% reduction of area

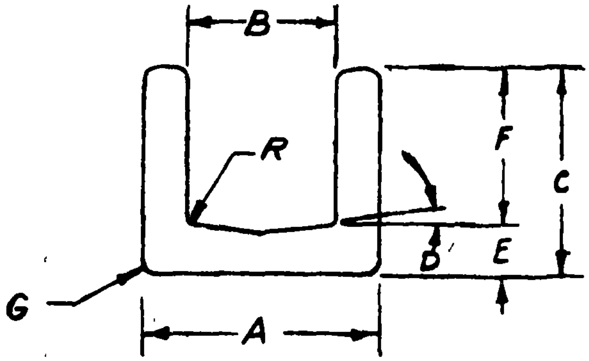


Fig. 5

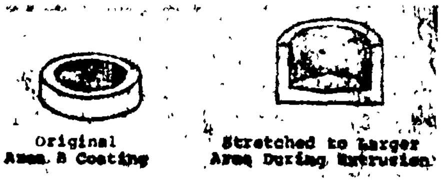


Fig. 6

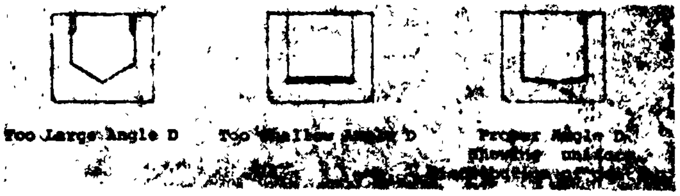


Fig. 7

is: 0.060 on a 1 in. diameter part and 0.090 on a 5 in. diameter part.

Angle D - Angles of 4-10 deg on steel and 1-3 deg for aluminum on this dimension are desirable for a new design. The proper angle can be only determined in die tryout. Once the proper angle has been established ±1/2 deg is ample tolerance. This angle is necessary because it is a metering device for the phosphate coating.

The total area represented on the finished cup by - (1). B circumference times length F (inside wall surface) plus (2) area of diameter B (bottom of cup area) on the slug--was only area of diameter B. This same small surface on the slug during extrusion was stretched into the much larger surface area of the total inside area of cup. (See Fig. 6.)

The function of the angle D is to stretch this coating uniformly. If this angle is too shallow, all the coating will remain under punch and circumference B will gall or seize due to lack of coating. If this angle is too large, all the coating will at once move out from under the punch and be deposited at upper end of circumference B leaving no coating for lower end of circumference B, again causing galling and seizing. A delicate balance is necessary and should be determined in die tryout. (See Fig. 7.)

Too large angle D
Too shallow angle D
Proper angle D showing uniform distribution of coating.

Dimension E - A reasonable commercial tolerance is ± 0.005 on a 1 in. diameter part and ± 0.012 on a 5 in. diameter part. More is desirable. As mentioned under dimension C, hardness variation of the slug and press setting determines this tolerance.

This dimension should never be smaller than the wall thickness of the part for rupturing of the part and other undesirable features may happen. If a thinner bottom is necessary, it will have to be accomplished with secondary operations.

Dimension F - Same as dimension C.

Dimensions C, E, and F - The foregoing comments on these dimensions were meant to cover extrusions done in an open die with mechanical presses. Most backward extrusion is currently done this way. This does not apply to closed die backward extrusion. At present, closed die backward extrusion is only done on mechanical presses where very accurate slugs are obtainable. Closed die backward extrusion on hydraulic presses is relatively simple, but much slower and more costly.

Using a closed die, dimension F can be held to 0.002 on a 1 in. diameter part and 0.005 on a 5 in. diameter part. Dimensions C and E can be held to 0.02 on a 1 in. diameter part and to 0.06 on a 5 in. diameter part.

Corner G - A 1/16 radius on a 1 in. diameter part and a 1/8 radius on a 5 in. diameter part are most desirable, but almost any corner can be made.

Corner R - A tolerance of 0.040-0.060 is best on a 1 in. diameter part, but 0.015 tolerance from 0.020 to 0.125 depending on length F is possible. One of 0.050-0.070 is best on a 5 in. diameter part, but 0.020 tolerance from 0.030 to 0.125 depending on length F is possible.

Theoretically, a sharp corner would be best but it cannot be maintained because it would break down too soon. Therefore, the smallest controlled radius possible (versus one obtained through breakdown by wear) is best. A large radius causes excessive wear on punch on diameter B.

In forward extrusion the basic and easiest part is illustrated in Fig. 8.

Diameter A - Working with a closed die and normal reduction, a good commercial tolerance on mild steel 1 in. diameter would be 0.004 and on a 5 in. diameter, 0.010. Working with an open die where you are depending upon the column strength of diameter A to accomplish reduction required, the tolerance would be equivalent to the tolerances on the raw material purchased. It may swell on heavier reductions above corner F depending on clearances allowed on lead in angle.

Diameter B - A good commercial tolerance on a 1 in. diameter part would be 0.004 and on a 5 in. diameter part, 0.010.

Diameters A and B - Concentricity on a 1 in. diameter

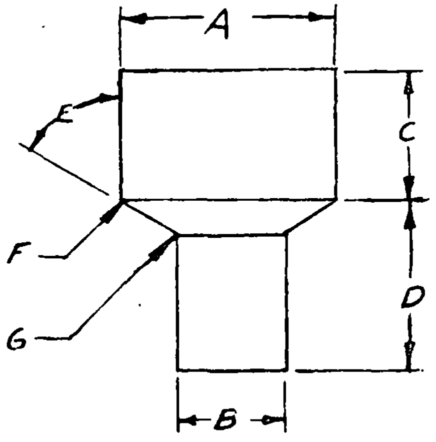


Fig. 8

part should be held to 0.002 and on a 5 in. diameter part should be held to 0.004, measured near corners F and G. As a part becomes longer, the bow must be taken into consideration as well as the concentricity. The bow can normally be held to 0.001 per 1 in. of overall length.

A simple classic extrusion as shown in mild steel with a closed die area of diameter B can be 10% of area of diameter A (90% of reduction of area). With an open die 30% reduction of area is possible.

In an open die, the present maximum unsupported length that can be extruded under normal conditions is 12 diameters. The factors that affect this ratio are: temper of material used, alloy content, surface condition and lead diameter.

Dimension C - On a mechanical press ± 0.005 on a 1 in. diameter part and ± 0.008 on a 5 in. diameter part is a reasonable commercial tolerance. More is desirable. The two elements causing variation on this dimension are: press setting and hardness variation of the slug causing varying press deflection.

Dimension D - This is a very difficult dimension to hold on a mechanical press: 1/8 in. on a 1 in. diameter part, and 5/8 in. on a 5 in. diameter part, on a part with 30% reduction of area would be desirable. The elements causing variation on this dimension are:

1. The original volume or weight variation of the slug.
2. Press setting.
3. Hardness variation of slug.
4. Die wear causing volume variation on part.
5. Spring back of part.

Dimensions C and D - On a hydraulic press, tolerances for C and D are interchangeable. By running the free floating end diameter B against a stop block, the normal variation incident to dimension D can be absorbed by dimension C. Consequently, the choice between which dimension to hold closely and which to allow to vary is left to the designer.

Angle E - The ideal angle from a production standpoint could vary from 10 deg to 88 deg depending on the following factors:

1. Reduction of area.
2. Analysis of material.
3. Hardness of material.
4. Hardness desired on finished part.
5. Closed or open die to be used.
6. Equipment limitations.
7. Die finish.
8. Coating variation.

If possible, it would be best to leave this dimension open to be determined at die tryout. Once the proper angle has been established then ± 1 deg is ample tolerance providing all other above conditions remain constant.

Corner F - Tolerances of 0.04-0.25R satisfactory with 0.12R ideal on 1 in. diameter part; and 0.06-0.75R satisfactory with 0.25R ideal on 5 in. diameter part.

Corner G - Tolerances of 0.03-0.375R satisfactory with 0.04R ideal on 1 in. diameter part; and 0.04-0.75R satisfactory with 0.06R ideal on 5 in. diameter part.

These radii, F and G, are very rough figures. It is best to give the extruder all the latitude possible. On these radii depend extension pressures required, knock out pressures required, and die life: thus, the diameter tolerance B that can be held. Once these radii have been established in tryout they can be held to a reasonably close tolerance providing all other conditions remain the same.

DESIGNING PROBLEMS

One of the major things to keep in mind about designing for cold extrusion is that we like to hit a piece of metal once and then let go.

For example, Fig. 9a shows the typical ideal backward extrusion. On the inside diameter, the punch is in contact with the work for only approximately 3/16 in. Once you have squeezed the metal out from underneath the punch face, around corner Z, you let go, and that ends it.

Fig. 9b illustrates a very poor design. Once the metal is squeezed out from underneath the punch face, around corner Y, it has already been work hardened. Yet, we are continuing to drive the work hardened metal into a taper and around corner X. As has been mentioned before, even in a classic cold extrusion, we are using pressures close to the ultimate yield of our tool steels. But in this design, we are deliberately loading the punch far more than in the ideal shape and still expect our punch to stand up. It will not. It will bulge or break.

Fig. 9c has the same undesirable characteristics. On top of this no lubricants are being trapped under the punch to be metered out during the extrusion stroke. If the punch should stand up for a few pieces, all the lubricants would concentrate near the top edge of the inside diameter and real bright and shiny bottom inside diameter. This means that if the punch stood up in spite of the high pressures required,

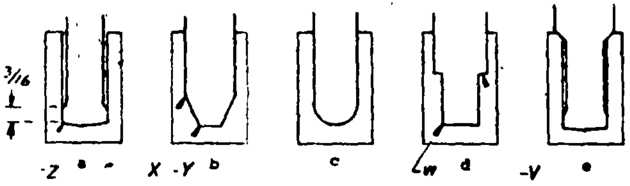


Fig. 9

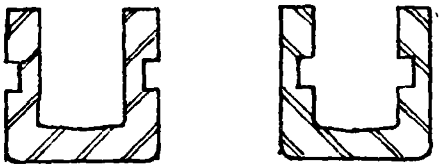


Fig. 10

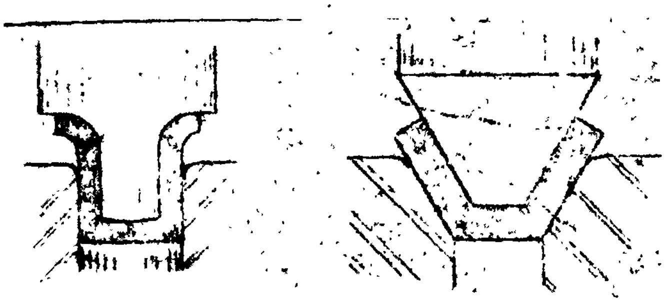


Fig. 11

it would still wear out in a very short time, due to no lubricant during the last part of the stroke.

Fig. 9d is a typical example of stepping on the brakes and gas at the same time. You are trying to push out the metal from underneath the punch face, around corner W, then putting on the brakes with face V, on metal which has already been work hardened. It is sometimes possible on a small job where the volume is very accurately controlled to come up and kiss it on a shoulder to provide a slight chamfer as illustrated in Fig. 9e, but I would do no more work there than absolutely necessary.

We can not, of course, produce undercuts as in Fig. 10. It would be impossible to remove parts from tools. Another thing that sounds logical is to try to backward extrude and expand at the same time as in Fig. 11.

The work hardened metal will not take it on a production basis. Successful extrusion is done by keeping metal under compression. Here, it is in tension and will split.

Knowing what metal wants to do is part of the art of cold extrusion. No one knows all the answers. There is still much unexplored territory especially in nonsymmetrical shapes. What we do know about extrusion is based on today's conditions but some of what is impossible today will be done tomorrow.

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centro de educación continua
división de estudios superiores
facultad de ingeniería, unam

DISEÑO DE HERRAMENTAL

LAMINACION

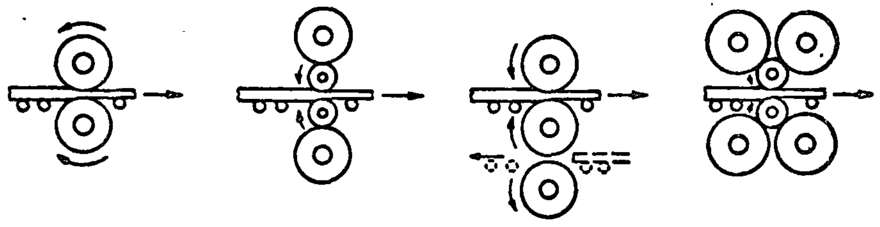
ING. ULRICH SCHARER SAUBERLI

JUNIO, 1978.

LAMINACION

Grooved Rolls End Smith's Supremacy

In 1783, the patent for a mill with grooved rolls was issued to Henry Cort of Fontley, England. With this mill, in combination with his perfected puddling furnace, he successfully converted old iron ship ballast into formed wrought iron for the British Navy. These developments ended the smith's long supremacy and opened the way for manufacture of shaped products by machinery. Iron, refined into steel, is now the universal metal, the lowest in cost, with the greatest range of uses. For more than half a century, Basic has provided refractories essential to steel's progress.



A. Tren laminador dúo, continuo o reversible

B. Tren laminador de cuatro rodillos con rodillos de respaldo para láminas anchas

C. Tren laminador trío para laminar hacia atrás y hacia adelante

D. Grupo laminador usando cuatro rodillos de respaldo

FIG. 1. Diferentes colocaciones de los rodillos, empleadas en los trenes laminadores

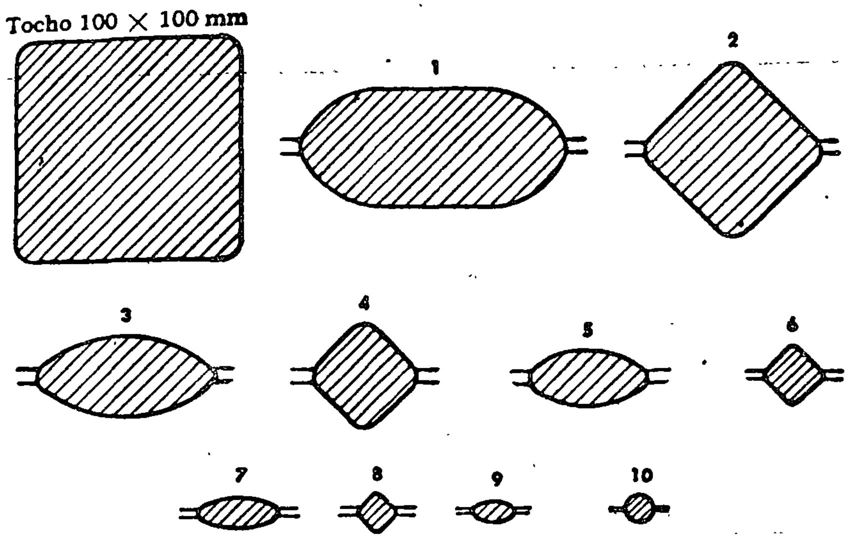


FIG. 2. Diagrama que ilustra el número de pasadas y la secuencia en la reducción, de la sección transversal de un tocho de 100 × 100 mm hasta barra redonda. (Cortesía de Carnegie-Illinois Steel Corporation)

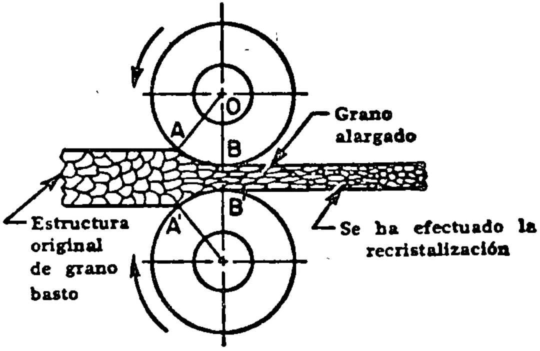
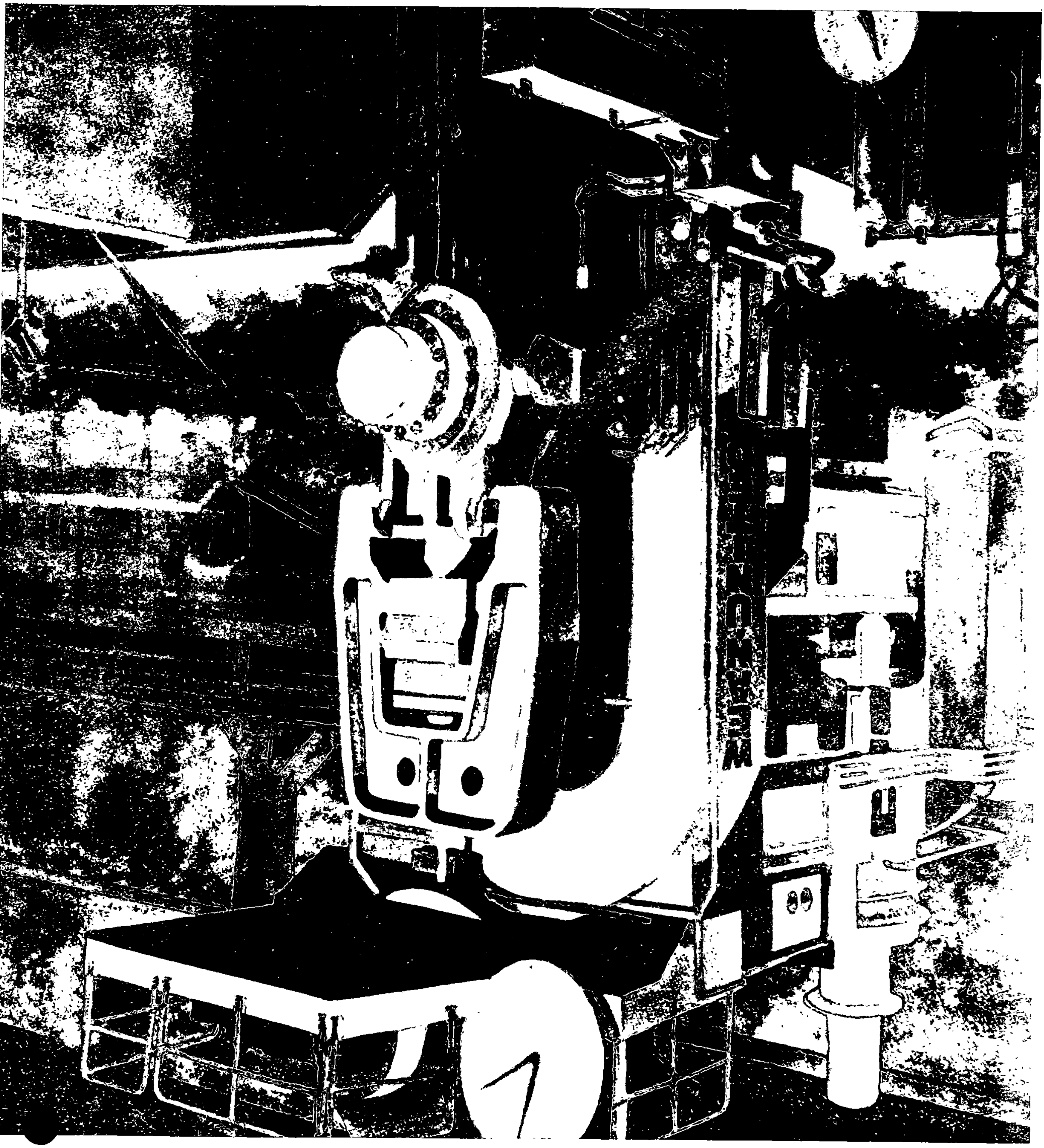
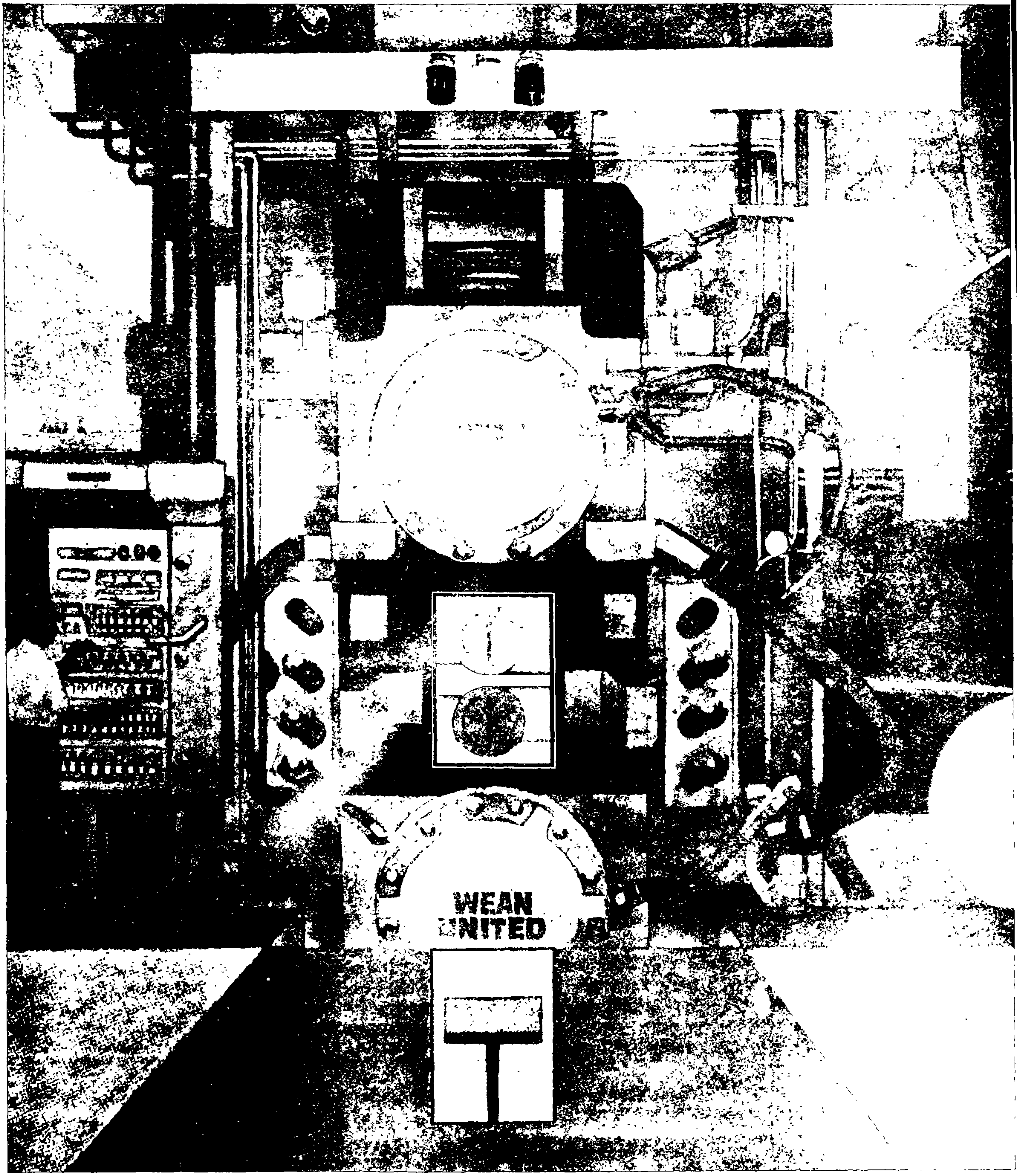


FIG. 3. Efecto del laminado en caliente, sobre la estructura del grano

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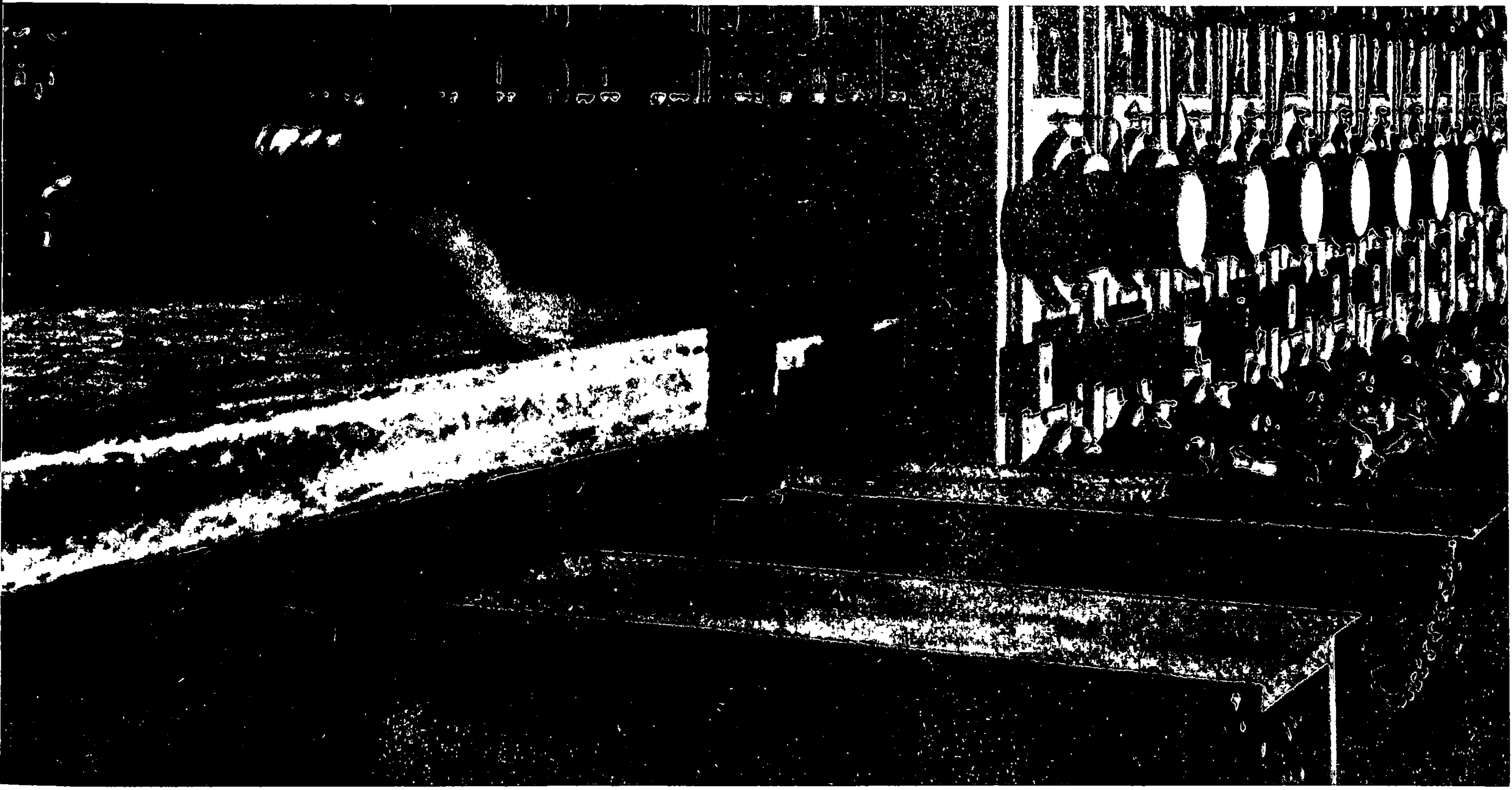
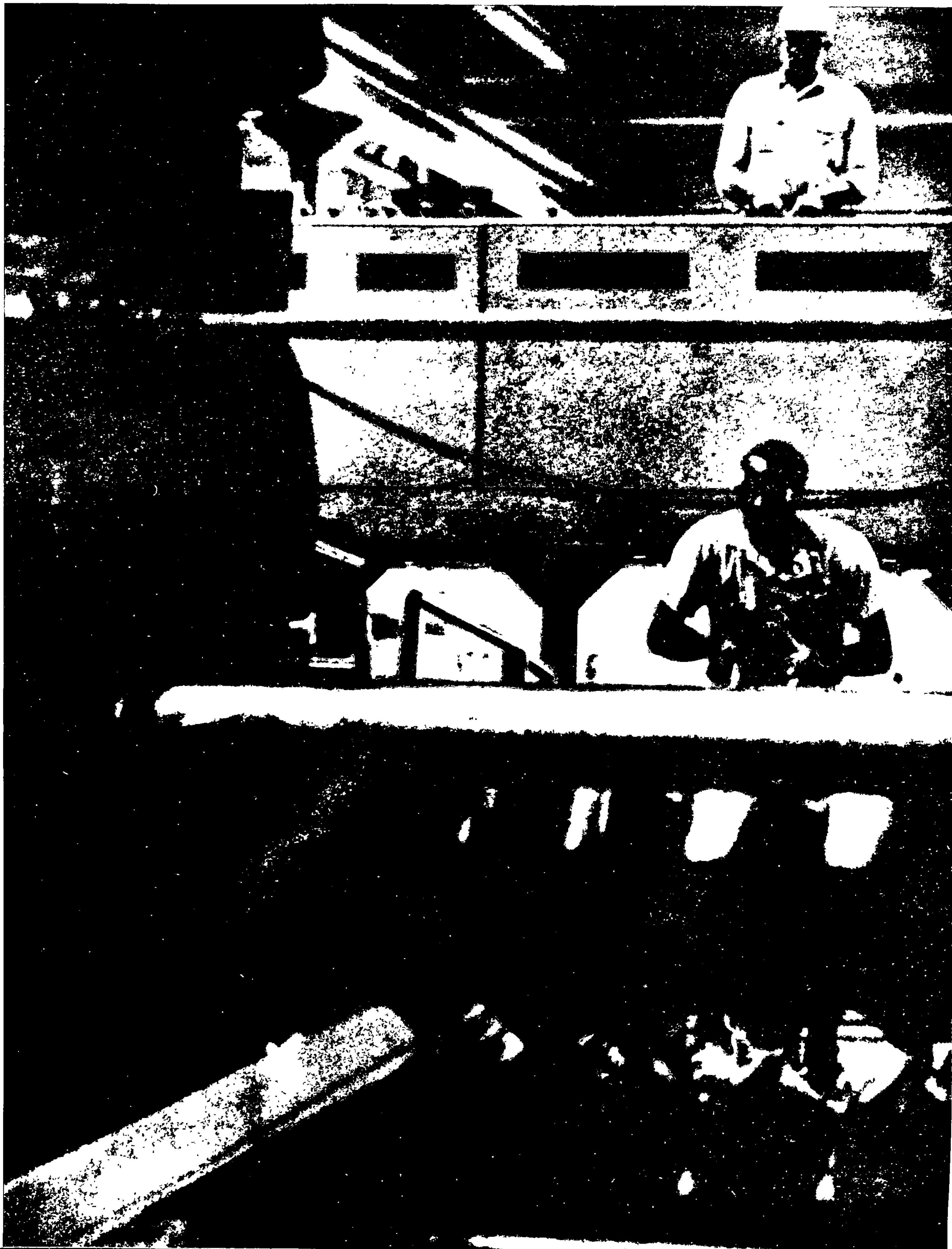
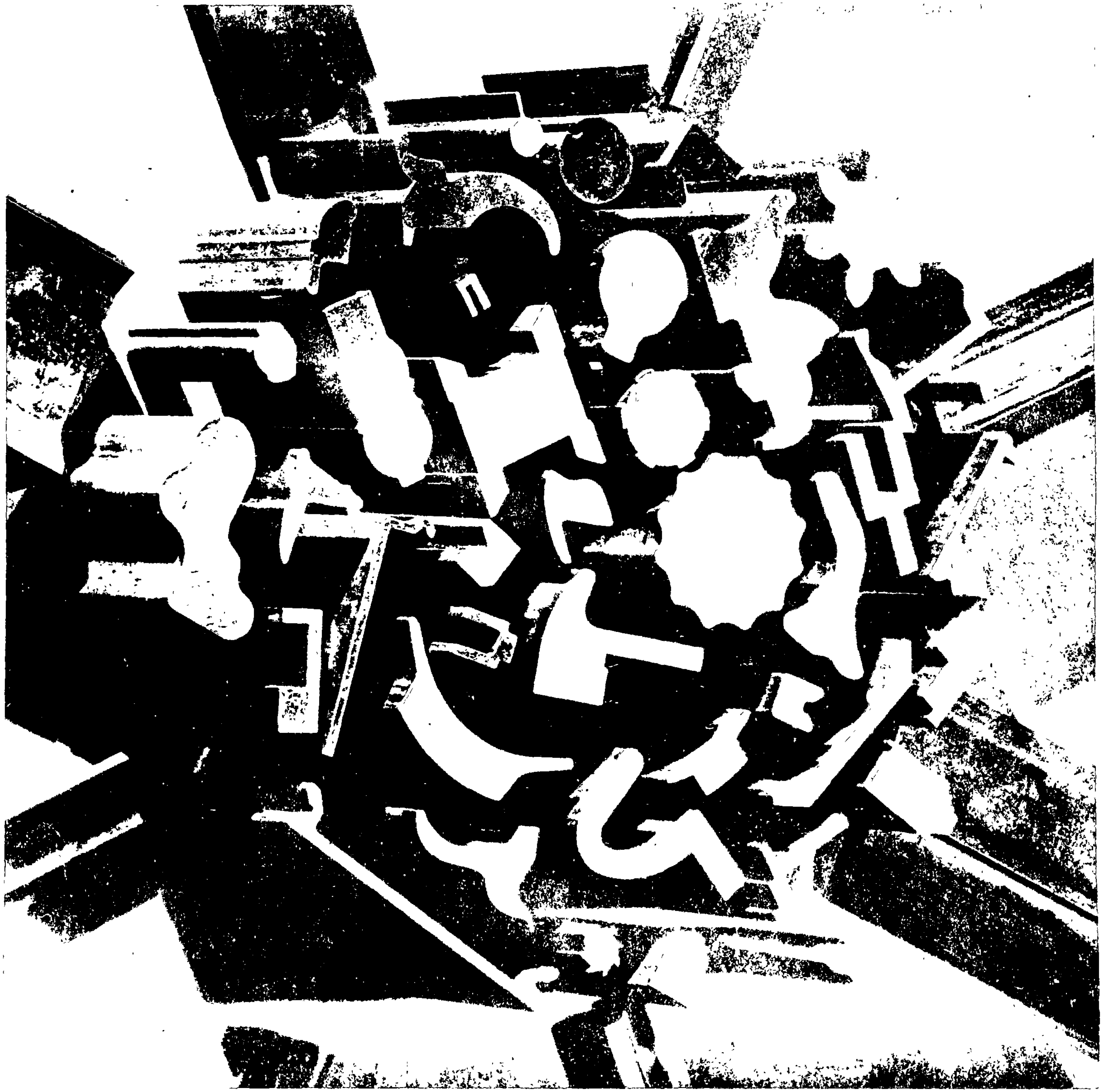
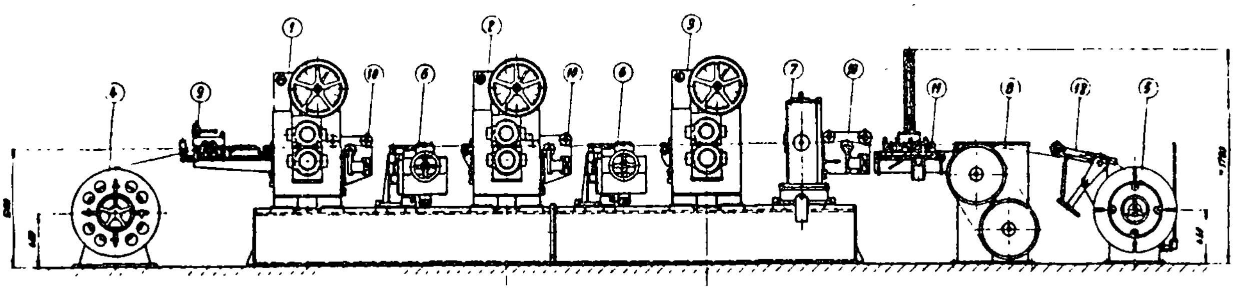








Los fabricantes de alambres planos de cobre exigen, en primer lugar, de una moderna instalación laminadora de alambres planos:

fidelidad en los perfiles; secciones conformes a las tolerancias.

superficies limpias, adecuadas para ser aislados.

velocidades de laminado y tiempos de preparación que correspondan a su capacidad de producción y que, sin embargo, permitan dominar ventajosamente cierta distribución por partidas de los pedidos.

Estas exigencias son satisfechas por la instalación laminadora múltiple, modelo I, que en una sola pasada obtiene perfiles planos laminados, totalmente terminados, de alambres redondos con diámetros hasta un máximo de 13 mm. Esta laminación se efectúa por el procedimiento húmedo.

El núcleo principal de la instalación lo constituye un accionamiento de corriente continua para sincronizar de tal modo los motores de impulsión, que los tiros preseleccionados para el alambre entre los distintos grupos permanezcan constantes.

La estación primera en el proceso de laminado la constituye la devanadera (4), cuyo sistema de freno asegura un tiro constante durante el devanado del alambre.

El alambre a continuación pasa por el bloque a rodillos verticales y horizontales del aparato enderezador (9). En orden a una mayor rapidez al enhebrar el alambre, se pueden abrir los grupos de rodillos para insertar el alambre, sin que por ello sufra modificación el reglaje hecho para el enderezamiento.

Después del aparato enderezador, el alambre es guiado por medio de guías de acero templadas y rectificadas con máxima precisión, que lo introducen en la embocadura del tren laminador (1).

Cojinetes de precisión de rodillos cónicos garantizan un perfecto giro de los rodillos laminadores exento de excentricidad.

El motor de corriente continua para accionar el tren de laminación (1) mueve los rodillos a través de un engranaje reductor con engranaje y árboles articulados.

El reglaje de aproximación del rodillo superior se lleva a cabo con ayuda de un volante de mano. Los husillos de reglaje tambien pueden ser ajustados individualmente, lo que hace factible el laminar perfiles asimétricos.

La escala de lectura indica un reglaje fino de aproximación hasta de 0,005 mm. Paquetes elásticos entre las piezas montadas cuidan de suprimir todo juego muerto en los órganos de aproximación de los rodillos. El desmontaje de los rodillos se lleva a cabo haciendo girar lateralmente hacia a fuera las piezas de montaje sobre carriles deslizantes. Bastidores de laminación cerrados y macizos, de fundición de acero, garantizan la exacta fidelidad de los productos laminados de acuerdo con las tolerancias.

El comprobador del tiro (10) emite impulsos hacia la regulación del tiro del accionamiento del tren laminador (2).

El aparato laminador de perfiles en alto (6) situado entre los laminadores (1) y (2) recalca y perfila el alambre abombado lateralmente. Los rodillos calibradores llevan suspensión al aire en orden a la mayor sencillez para recambiarlos. El aparato en conjunto es de una construcción muy rigida y ajustable con la linea de laminación.

Con el laminador (2) puede efectuarse de nuevo una pasada equivalente a la obtenida con el laminador (1). El aparato laminador de canto (6) entre el bastidor (2) y (3) está de nuevo previsto para perfilar las caras que resultaron abombadas en el bastidor (2). En el tren (3) se lleva a cabo el acabado de laminación, con una aproximación de pocas centésimas a la medida nominal. El último dispositivo laminador lo constituye en principio un aparato calibrador de 4 rodillos.

Con auxilio del aparato tractor (8) el alambre es pasado a través del calibrador. El aparato tractor está formado por dos tambores de acero estriados accionados a motor, alrededor de los cuales el alambre terminado es arrollado aproximadamente con unas tres vueltas. Gracias al efecto de fricción del alambre, se consigue el paso a través del calibrador sin que el alambre sufra el menor daño. El motor de corriente continua del aparato tractor es regulado, por medio del comprobador de tiro (10), para suministrar un esfuerzo de tiro constante.

El aparato medidor (11) controla las tolerancias tanto en el ancho como en el espesor del alambre terminado durante su paso, señalando por vía óptica sus variaciones.

El último puesto de la instalación lo constituye el grupo de recogida (5). Su motor de corriente continua está regulado para suministrar potencia constante, es decir, el tiro permanece constante durante la recogida del alambre terminado. Un pistón hidráulico alimentado por una bomba regulable produce el movimiento de vaivén del tambor de recogida. La velocidad ajustada para este movimiento de vaivén va siendo proporcionalmente menor a medida que aumenta el diámetro del rollo, ya que la bomba regulable es accionada directamente por el motor de impulsión del puesto de recogida.

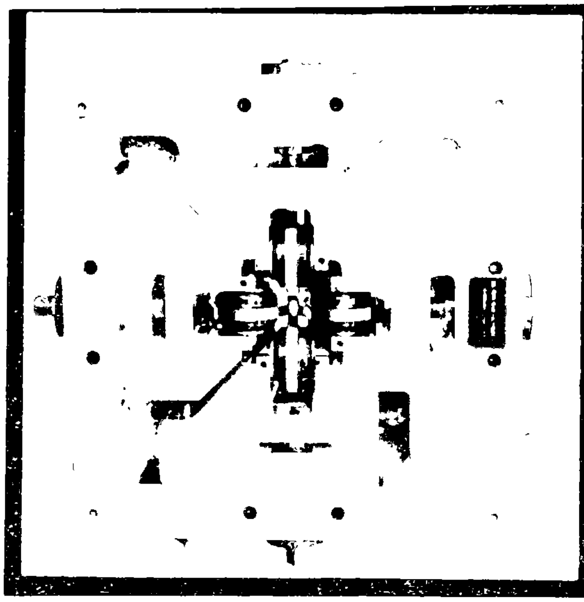
Los trenes de laminación, los aparatos laminadores de canto y el calibrador se hallan montados sobre una placa de base común.

Dicha placa de base sirve simultáneamente de depósito para el liquido refrigerante de laminación.

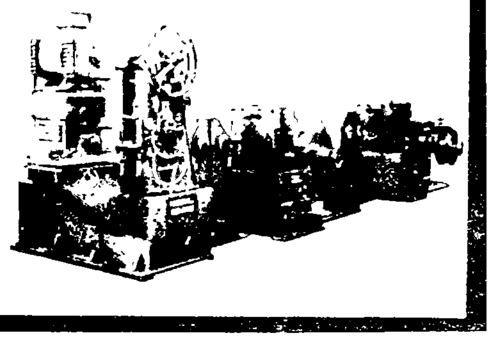
Un pupitre central de mando y control está previsto para gobernar y supervisar todo el proceso de laminado. Bloques individuales de control y maniobra en los distintos equipos que constituyen la instalación permiten llevar a cabo las manipulaciones necesarias para introducir el alambre y para aumentar la marcha hasta alcanzar la velocidad de laminación.

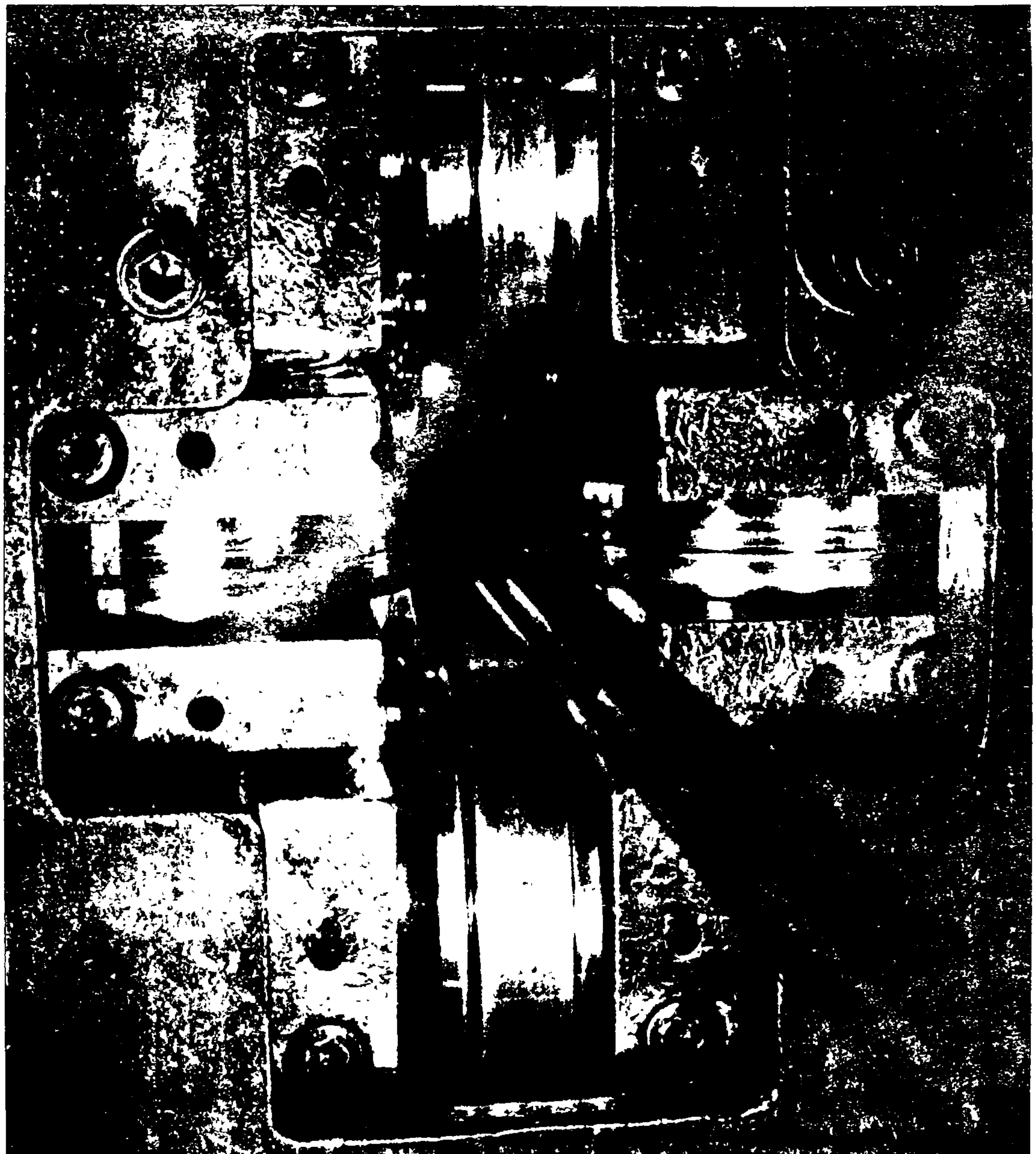
Caracteristicas técnicas

Material a laminar	Cobre
Material de partida	Alambres redondos 1,2-13 mm ⌀
Perfiles terminados (ejemplos) . . .	0,8 ± 0,01 × 1,4 ± 0,015 / 3,5 ± 0,02 × 19,5 ± 0,07 mm
Dimensiones de los rodillos	⌀ 220 × 150 mm
Velocidad de laminado	0 : 80 : 240 m/min
Motor del tren laminador 1:	N = 0 : 30 : 30 CV
Motor del tren laminador 2:	N = 0 : 30 : 30 CV
Motor del tren laminador 3:	N = 0 : 20 : 20 CV
Velocidad para el enhebrado del alambre	10 m/min.



MARSHALL
RICHARDS





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DISEÑO DE HERRAMENTAL

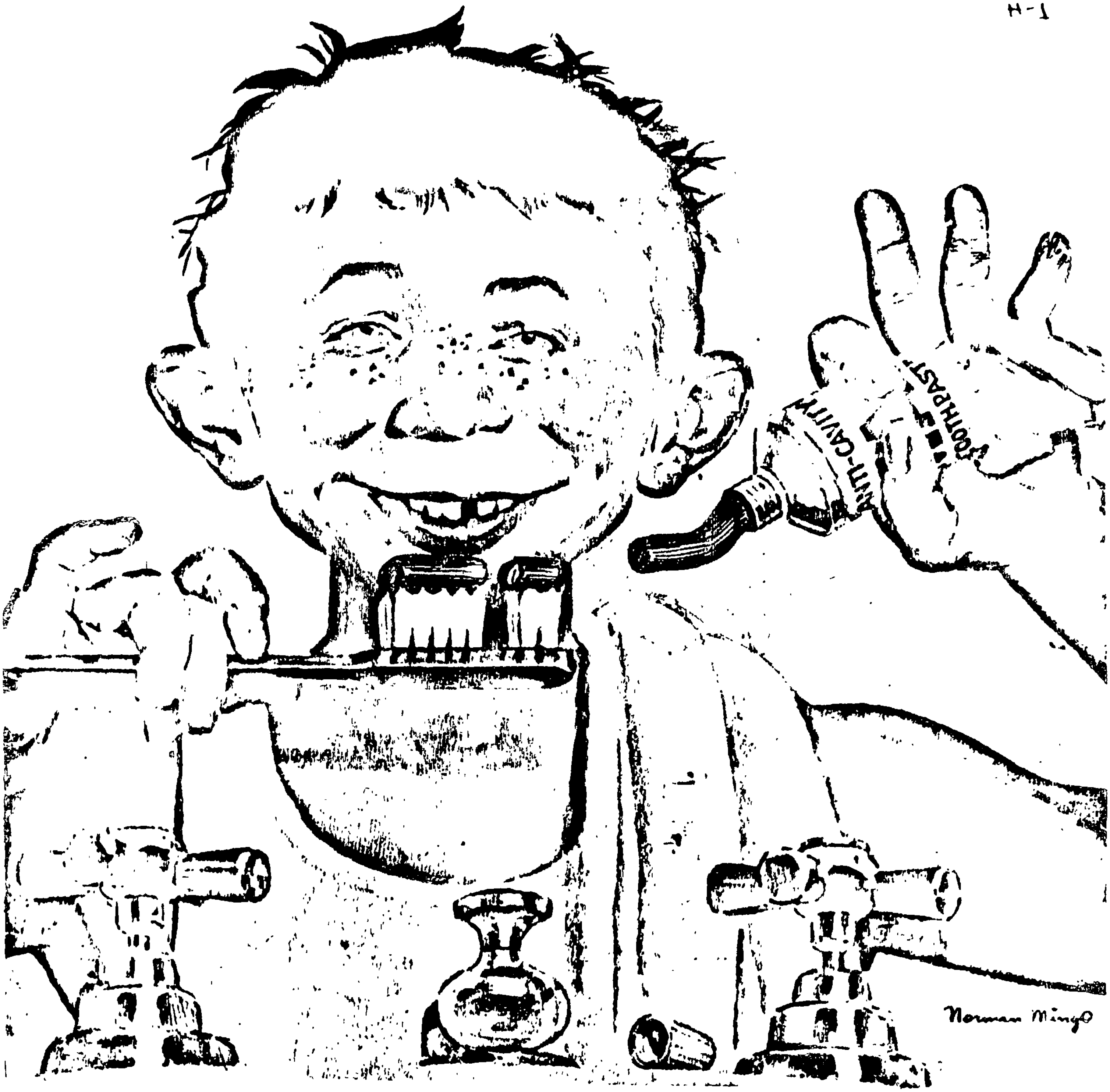
EXTRUSION

ING. ULRICH SCHARER SAUBERLI

JUNIO, 1978.

EXTRUSION

H-1



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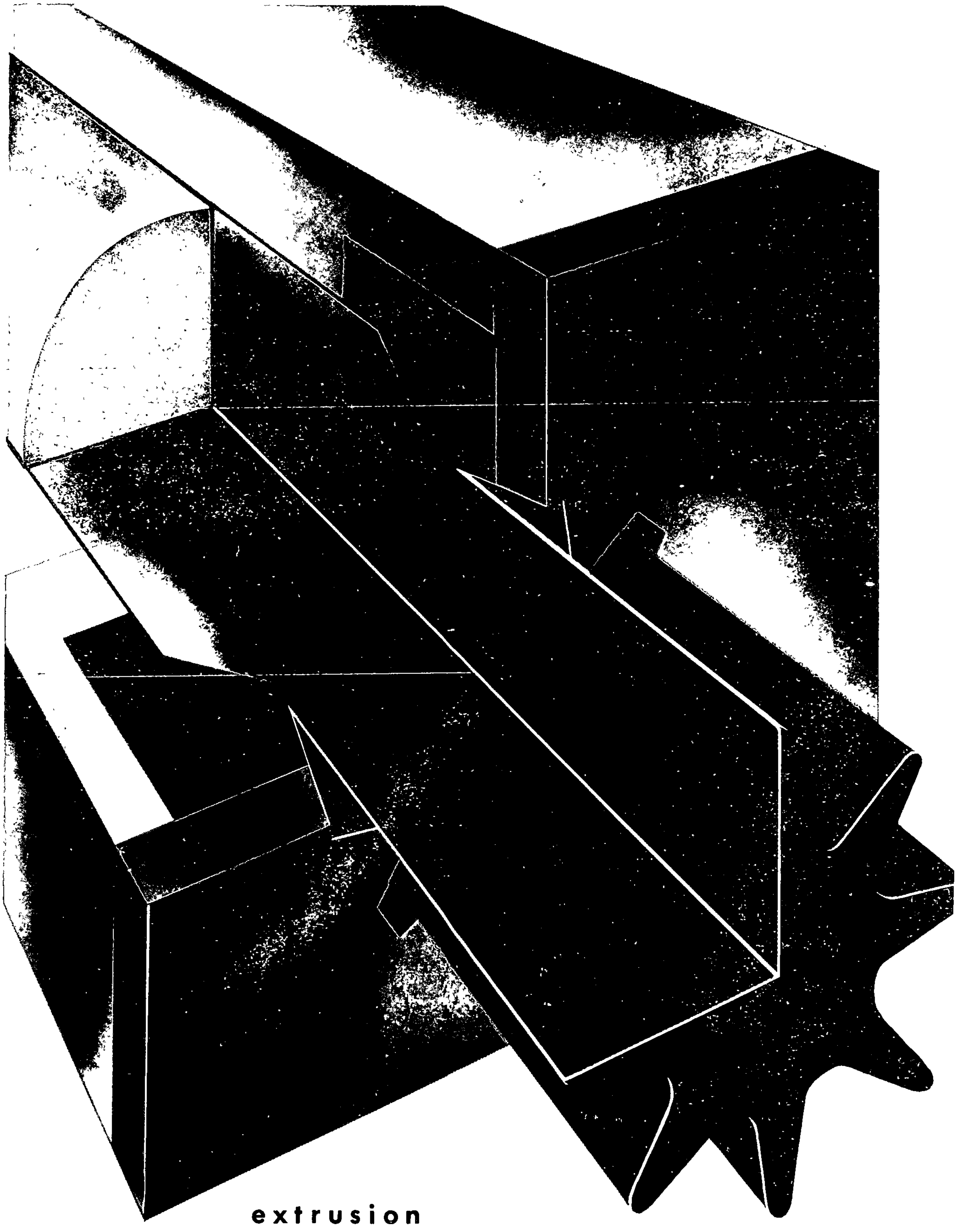


extrusion

SOME PRINCIPLES OF EFFECTIVE ALUMINUM EXTRUSION DESIGN

Other Methods **Extrusion**

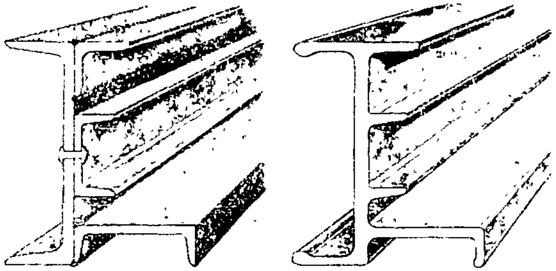


Fig. 4 — Several rolled structural steel shapes can be combined into a single aluminum extrusion, thus eliminating joining costs.

Fig. 5—Because extrusions permit changes of cross section, they can be "tailored" more readily than roll-formed sheet sections to meet specific design requirements.

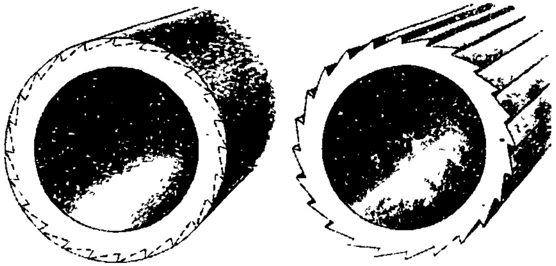


Fig. 6—Sections machined from bar stock or pipe can often be replaced by aluminum sections extruded to exact shape and size.

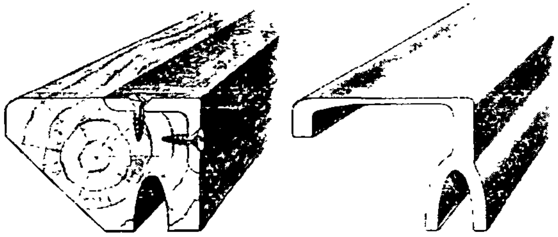


Fig. 7 — Aluminum extrusions are free from the warping and splintering often associated with wood sections. The aluminum shapes can often be made lighter, stiffer and stronger. Necessity for metal reinforcement is eliminated

Other Methods **Extrusion**

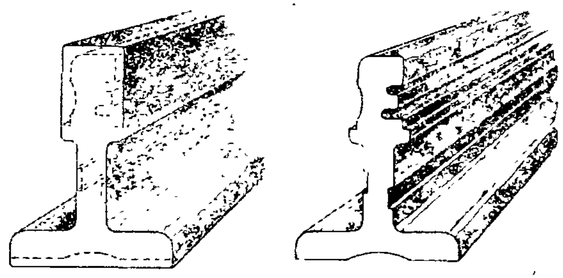


Fig. 8—Machining cost of long cast iron frame members is minimized by redesigning the section to an aluminum extrusion.

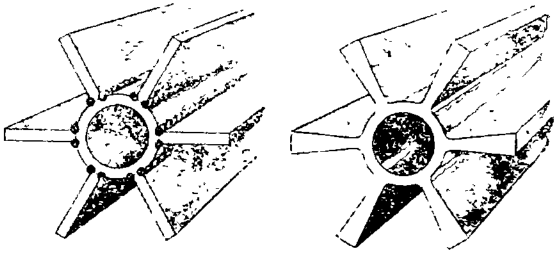


Fig. 9—Welded assemblies can often be redesigned to extrusions. Cost is reduced and strength and accuracy improved.

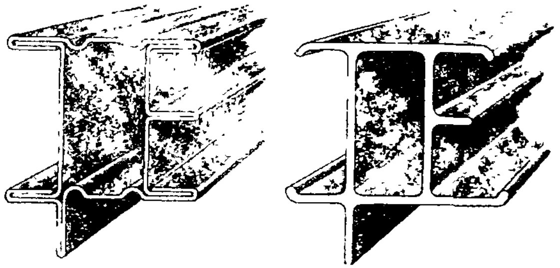


Fig. 10 — Crimped tubular sections often permit redesign to extrusions with gain in stiffness and strength. Too, cost can be reduced.

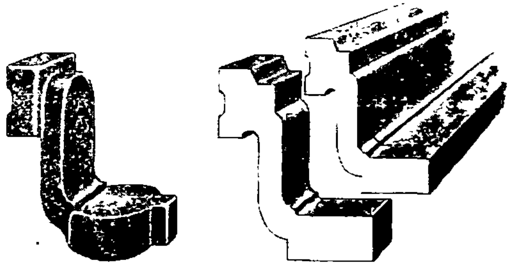


Fig. 11 — Small castings, forgings or parts machined from bar stock may permit redesign to an extruded shape, if their cross sections are symmetrical in one plane.

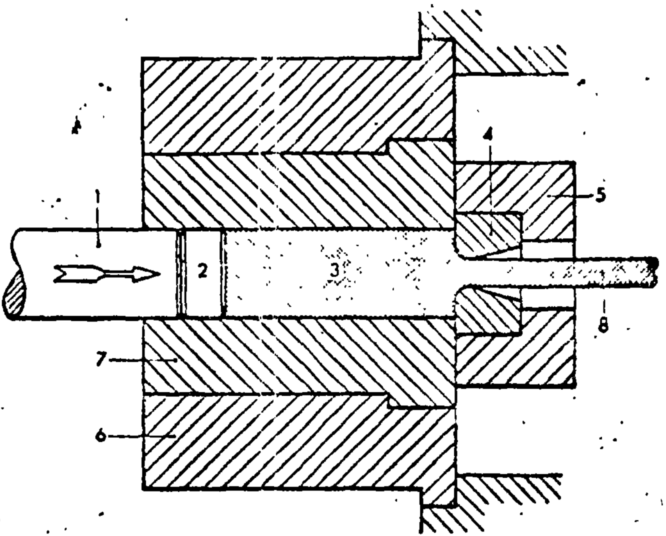


Abb. 118

Strangpressen von Stangen und Profilen
(direktes Verfahren)

1 Preßstempel
2 Preß- oder Vorlegescheibe
3 Aufnehmer (Preßling, Rohling)
4 Preßmatrize
5 Matrizenhalter
6 und 7 Aufnehmermantel und -büchse
8 gepreßte Stange (Profil)

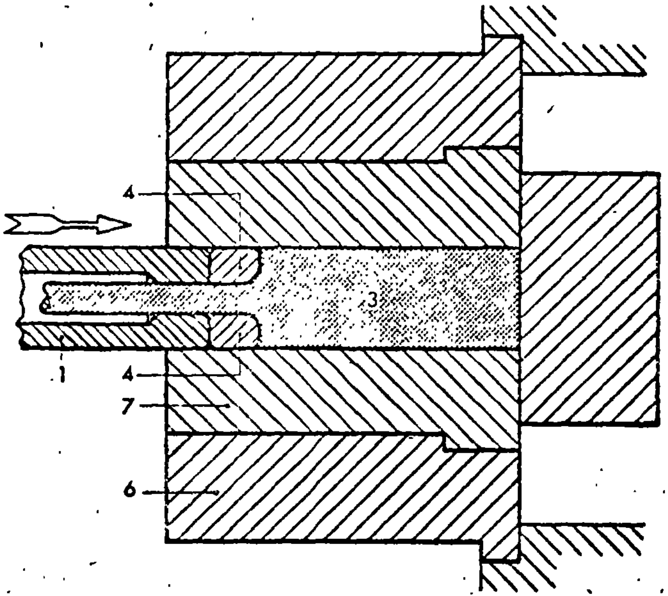
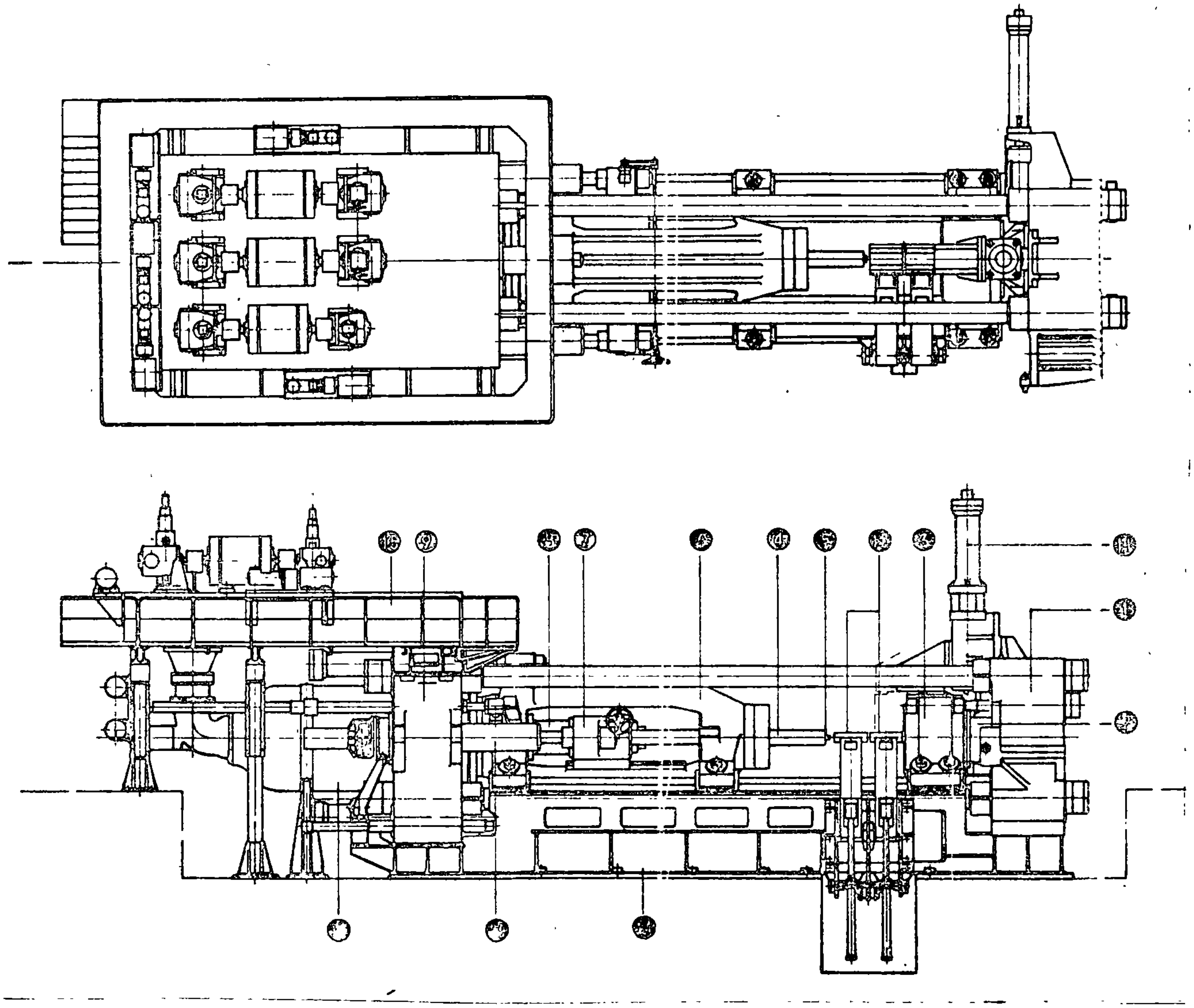


Abb. 119

Strangpressen von Stangen
(indirektes Verfahren)

1 Preßstempel
3 Aufnehmer (Preßling)
4 Preßmatrize
6 Aufnehmermantel
7 Aufnehmerbüchse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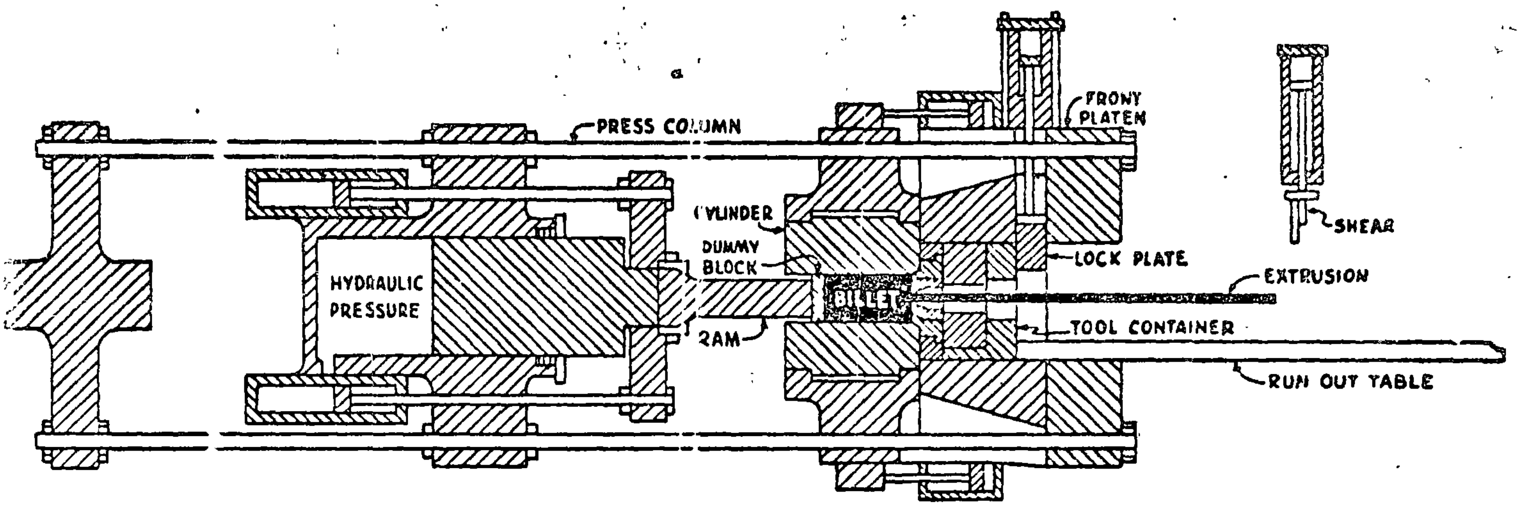


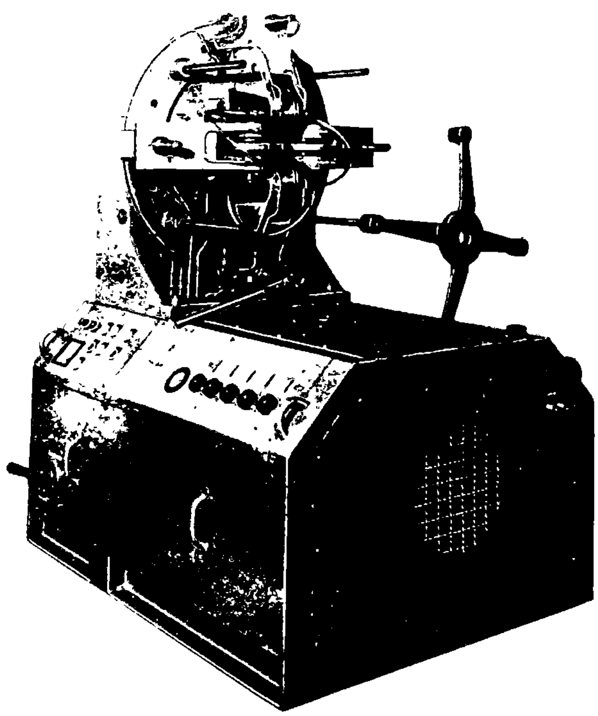
Fig. 50—Extrusion press used for producing aluminum shapes is shown in this schematic illustration. Hydraulically operated ram pushes hot aluminum through die opening of desired cross section. Extrusion tools are shown in detail in Fig. 51.

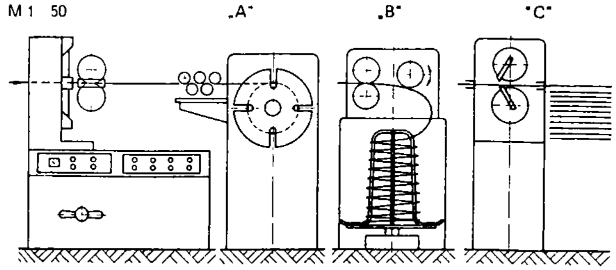
TABLE 62-2. COLD-EXTRUSION PRESSURES FOR COMMON METALS[6]

Material	Pressure, Tons/Sq In.
Aluminum alloys	40–70
Brass (soft)	30–60
Copper (soft)	25–70
Steel C1010 "extrusion grade"	50–105
Steel C1020 (spheroidized)	60–200

TABLE 62-1. TYPICAL CONDITIONS REQUIRED FOR HOT EXTRUSION[5]

Metal	Pressure, psi	Temp, deg F	Container temp, deg F	Extrusion speed, fpm
Aluminum alloys	40,000–100,000	....	50° below billet	1½–300
1100, 3003, 3004, 5052	....	750–900		
2014, 2017, 2024	....	650–850		
4032, 6151, 6061, 6063	....	700–900		
Copper alloys	30,000–120,000	....	Preheat	Not critical
Architectural bronze	....	1200–1300		
Naval brass; leaded Naval brass	....	1200–1350		
Muntz metal, forging brass	....	1250–1350		
Free-cutting brass	....	1300–1400		
Aluminum bronze, 8 %	....	1350–1450		
Admiralty metal; high-silicon bronze	....	1400–1500		
Aluminum brass	....	1450–1550		
Red brass, 85 %	....	1450–1600		
Aluminum bronze, 5 %	....	1500–1600		
Copper	....	1500–1650		
Cupronickel, 20 %	....	1800–1900		
Cupronickel, 30 %	....	1900–2000		
Lead	40,000–60,000	400–500		
Magnesium alloys	5,000–50,000			
M1	....	780–820	680–730	20–100
AZ31X	....	700–750	450–600	15–40
AZ61X	....	700–750	450–550	7–20
AZ80X	....	680–750	450–550	4–7
Nickel; Monel; Inconel	100,000–120,000	2000–2300	Preheat	400–730
Steel	100,000–120,000	2000–2300	Preheat	400–730
Tin	40,000–100,000	140–150	....	10–30
Zinc	100,000–120,000	480–570		

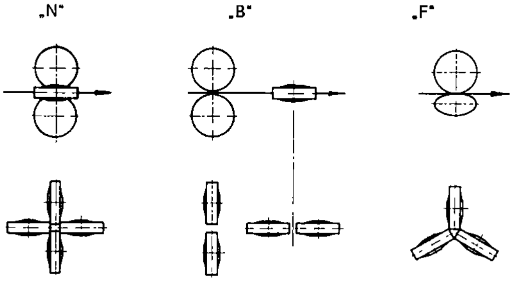




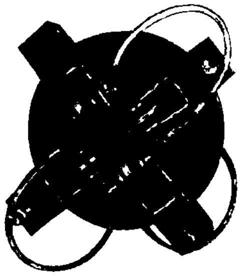
Typ AWG mit. Spuler oder Biegevorrichtung oder Schere

Maschinen- und Walzenkombinationsmöglichkeiten:

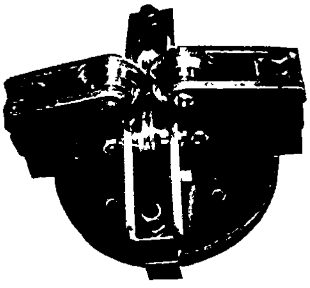
Walzenanordnung in.



PROFIL-WALZAPPARATE DBP System FUHR

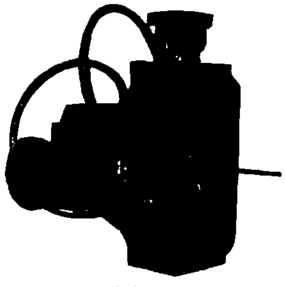


Normalausführung
für Profile



B-Ausführung
für Profile und Flachbänder

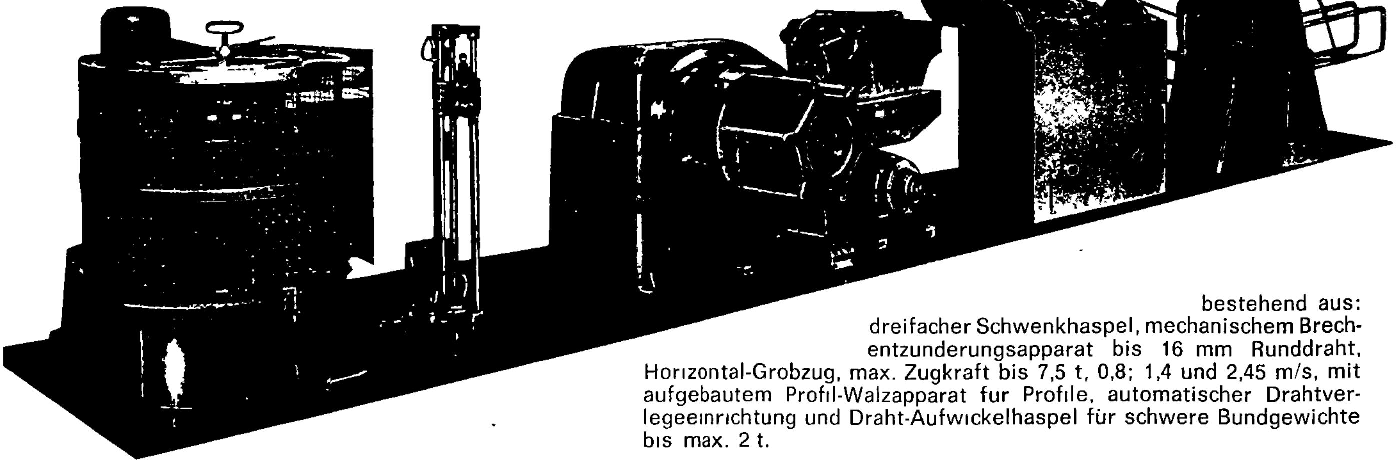
F-Ausführung
für Kerbprofile



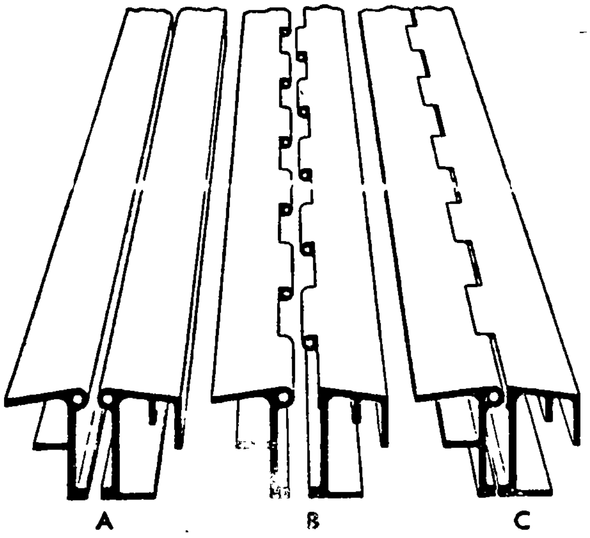
R-Ausführung
(Baukastensystem)
für Runddrähte

„RH"-Ausführung
(Arrondierung)
für Flachprofile

ZIEHANLAGEN für Kerb-, Profil- und Runddrähte



bestehend aus:
dreifacher Schwenkhaspel, mechanischem Brechentzunderungsapparat bis 16 mm Runddraht, Horizontal-Grobzug, max. Zugkraft bis 7,5 t, 0,8; 1,4 und 2,45 m/s, mit aufgebautem Profil-Walzapparat für Profile, automatischer Drahtverlegeeinrichtung und Draht-Aufwickelhaspel für schwere Bundgewichte bis max. 2 t.



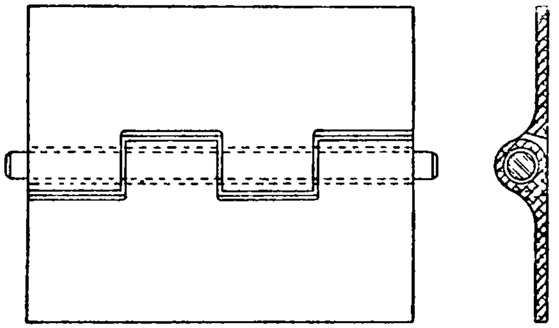


Fig. 43—Extruded hinge sections are frequently employed in aircraft design. A, sections as extruded; B, machined; C, assembled.

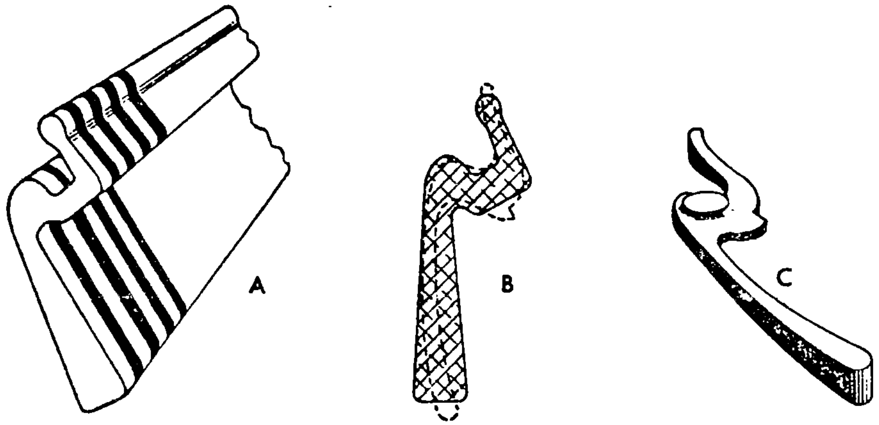


Fig. 44—Extruded stock for forging reduces cost of forging and trimming operation. A and B, extruded blanks; C, finished forging.

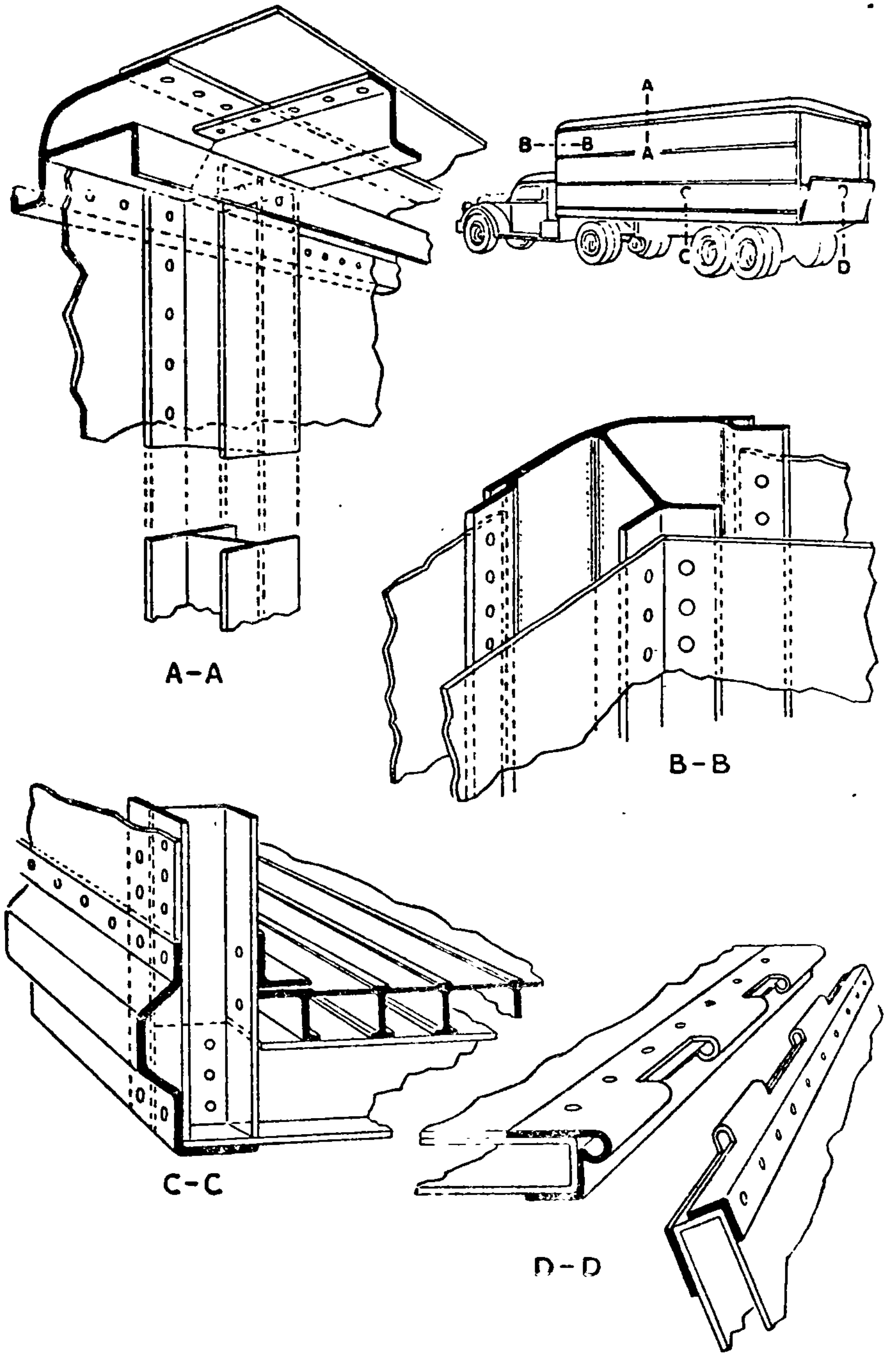
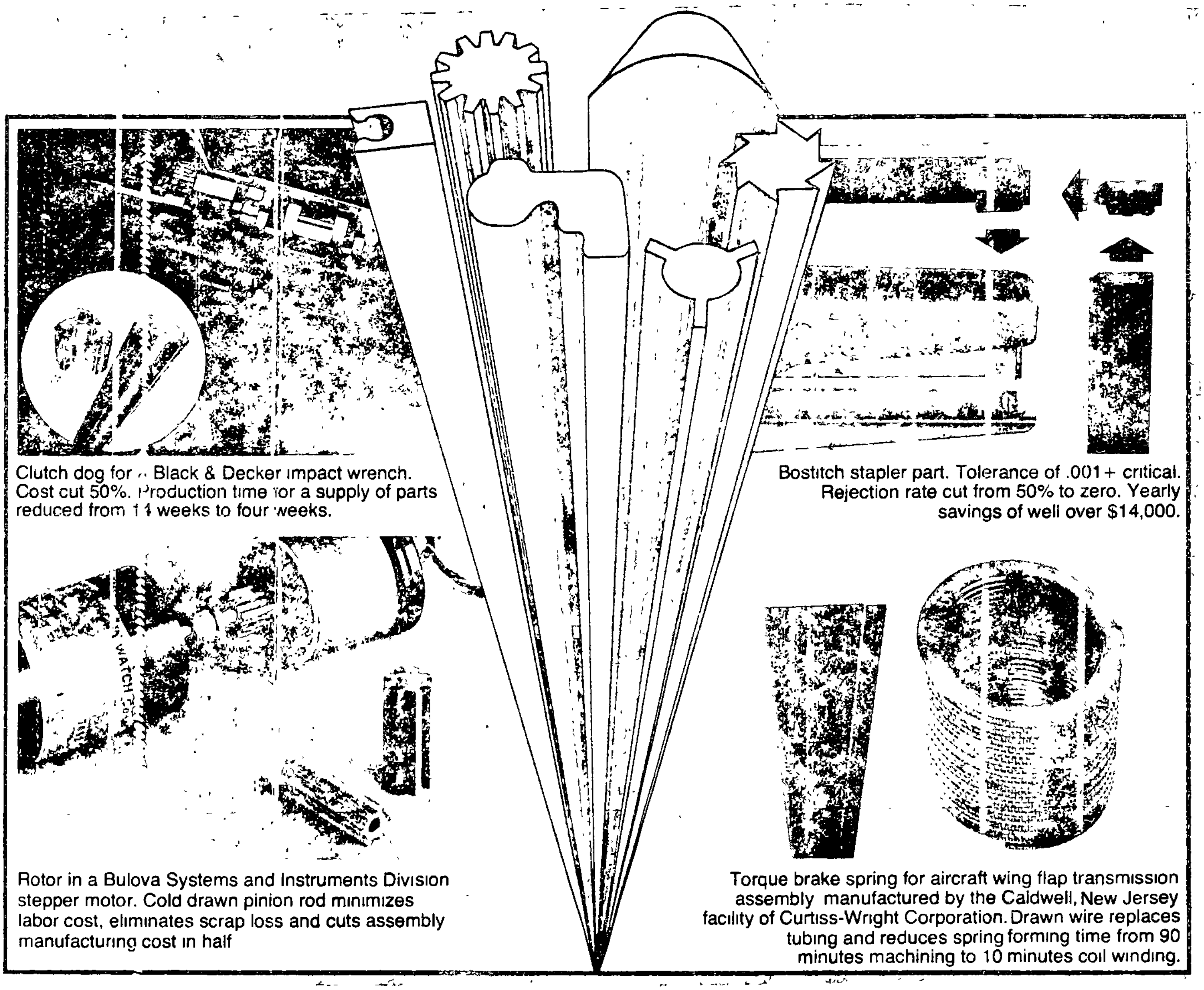


Fig. 15—In truck and trailer construction, extruded aluminum roof rails, roof bows, side and bottom sills, floor beams and tail gate sections save weight and reduce assembly cost. Extruded cross sections are shown black.



Clutch dog for a Black & Decker impact wrench. Cost cut 50%. Production time for a supply of parts reduced from 14 weeks to four weeks.

Bostitch stapler part. Tolerance of .001+ critical. Rejection rate cut from 50% to zero. Yearly savings of well over $14,000.

Rotor in a Bulova Systems and Instruments Division stepper motor. Cold drawn pinion rod minimizes labor cost, eliminates scrap loss and cuts assembly manufacturing cost in half

Torque brake spring for aircraft wing flap transmission assembly manufactured by the Caldwell, New Jersey facility of Curtiss-Wright Corporation. Drawn wire replaces tubing and reduces spring forming time from 90 minutes machining to 10 minutes coil winding.

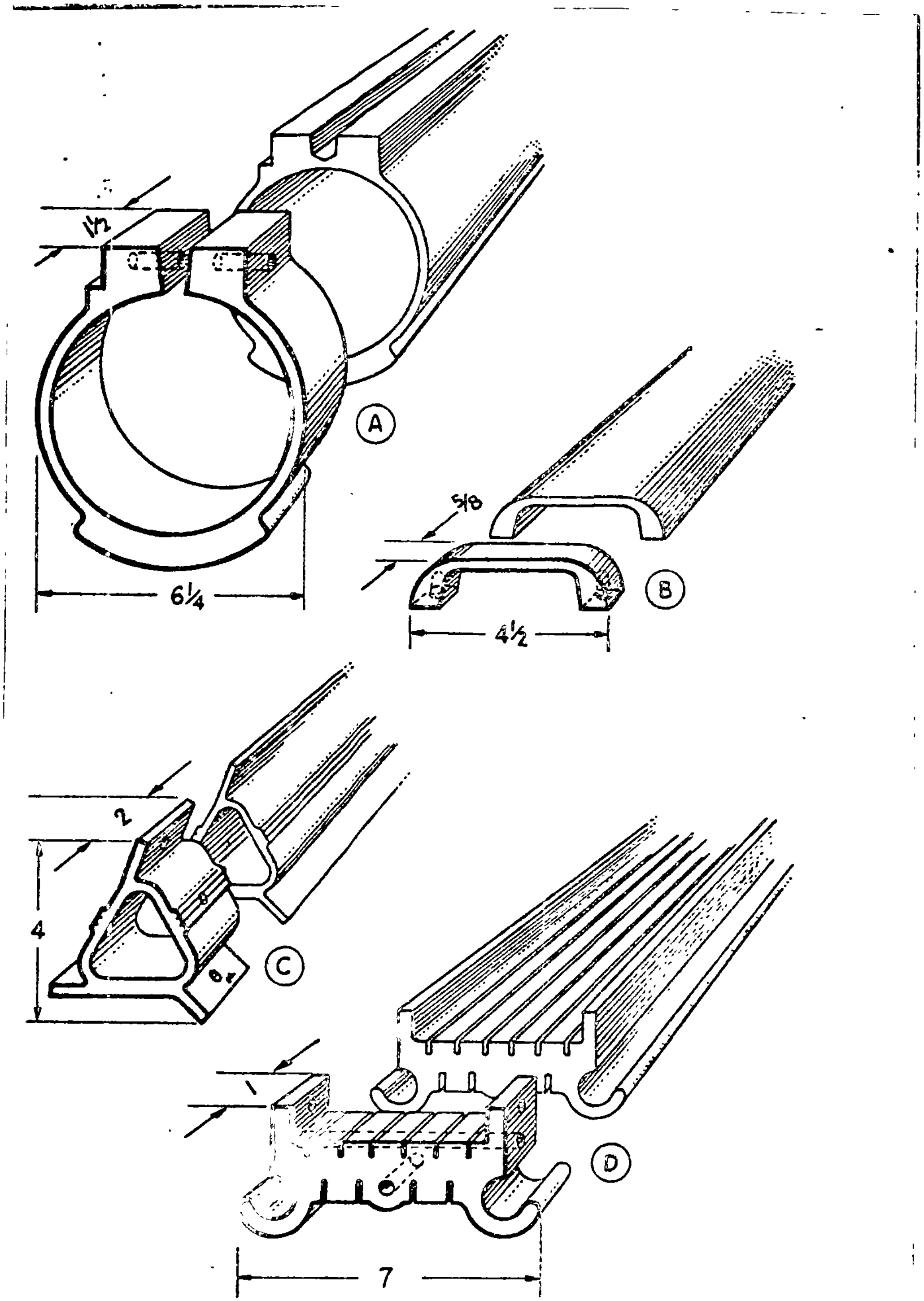


Fig. 42—Short parts cut from extruded shapes are often cheaper than castings, forgings or parts machined from bar stock. Examples illustrated are A—clamp for coupling for aluminum irrigation tubing, B—drawer pull, C—clamp for tripod, D—loom part.

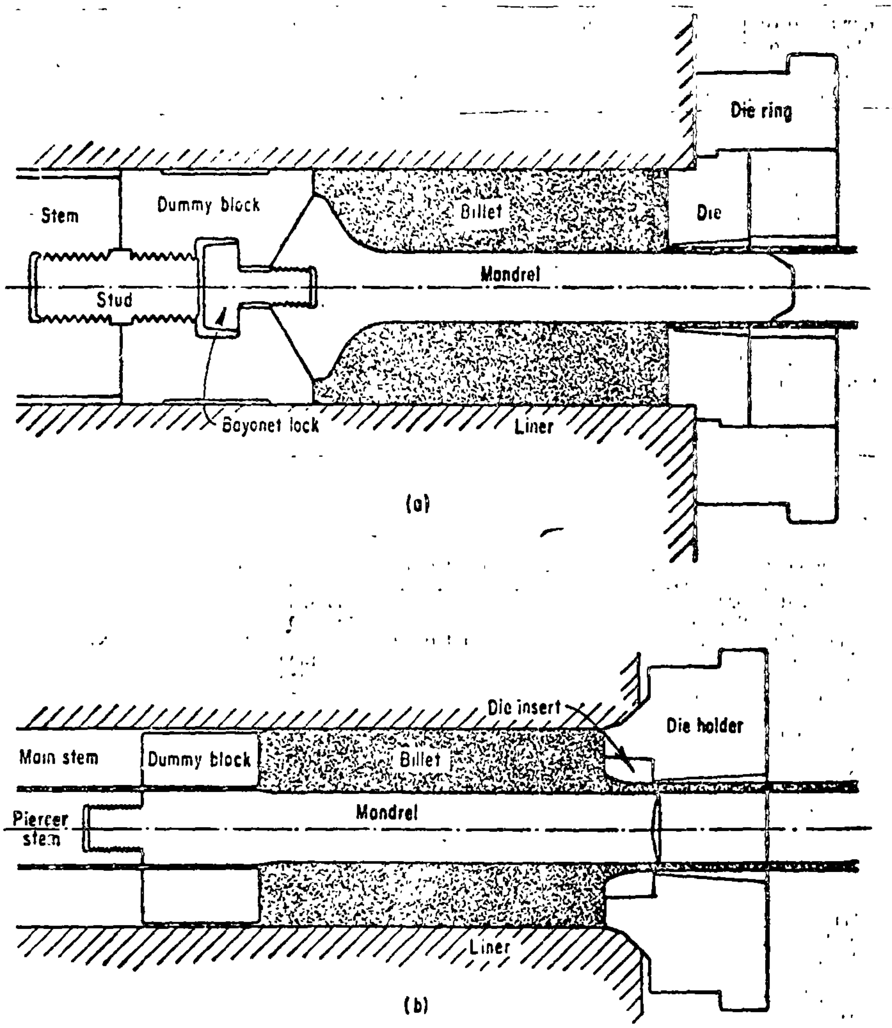
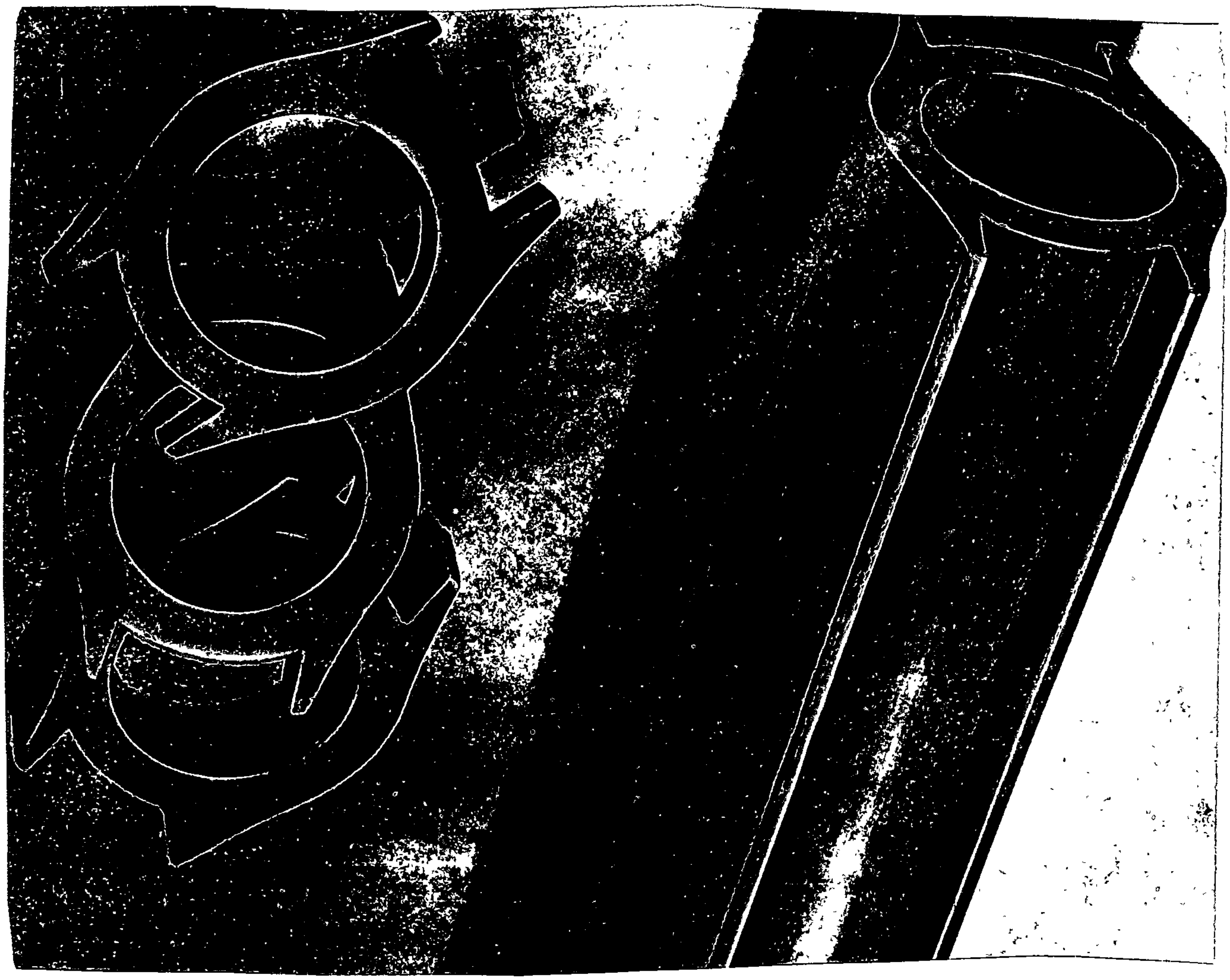


FIG. 52-5. Mandrels for hollow extrusions: (*a*) floating-bayonet type; (*b*) piercing type. (*Morzik Tool & Die Works.*)



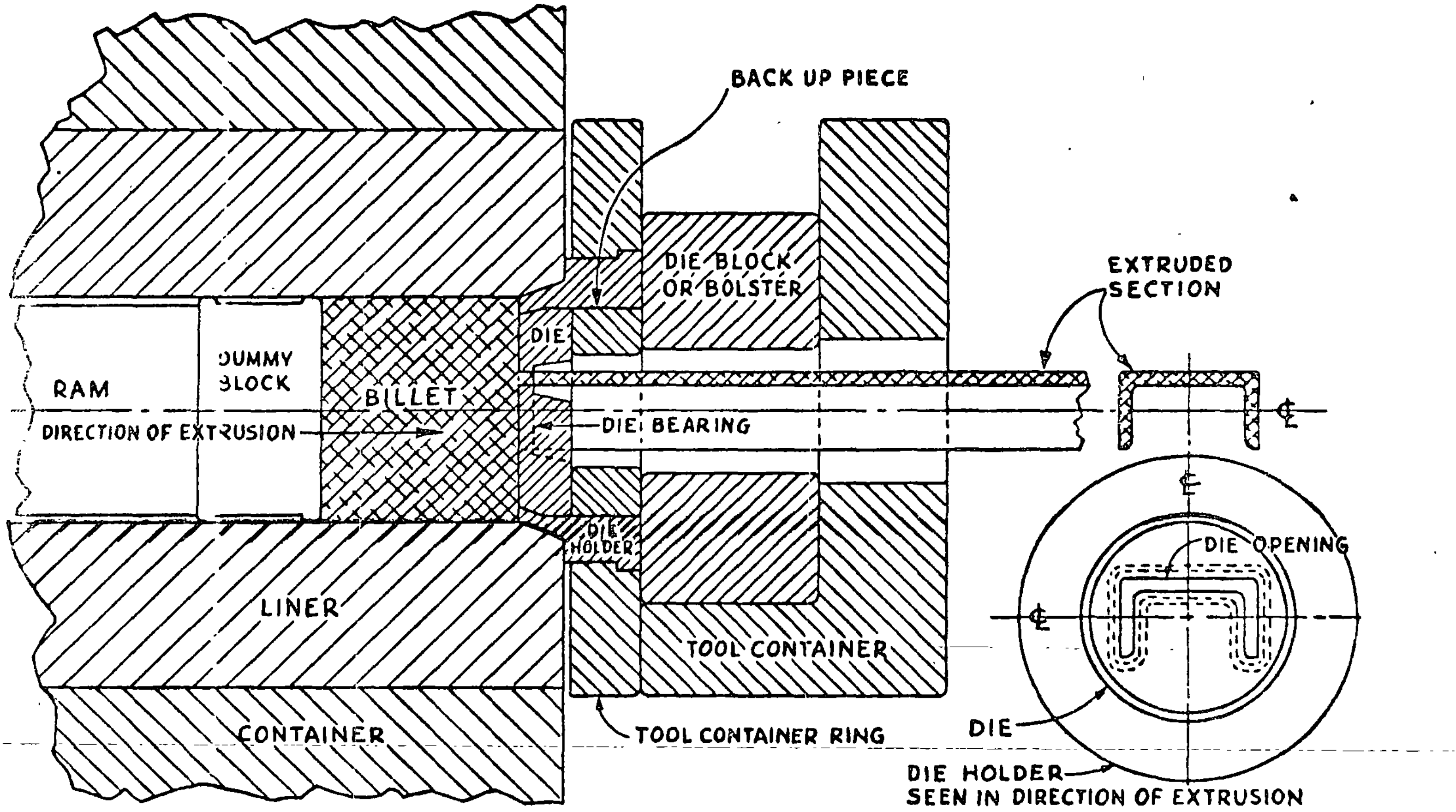


Fig. 51—Steel tools for producing aluminum shapes consist of die, back-up block, die holder, die block and tool container. Extrusion billet diameters range from 4 to 11 inches.

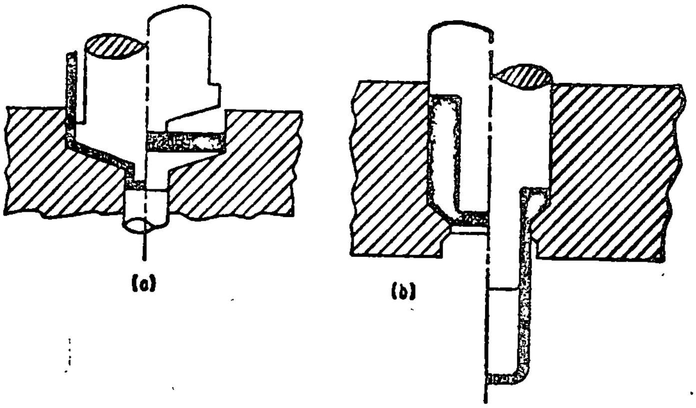


Fig. 52-11. Schematic representation of extrusion process: (*a*) impact or backward extrusion; (*b*) uniform pressure or forward extrusion.

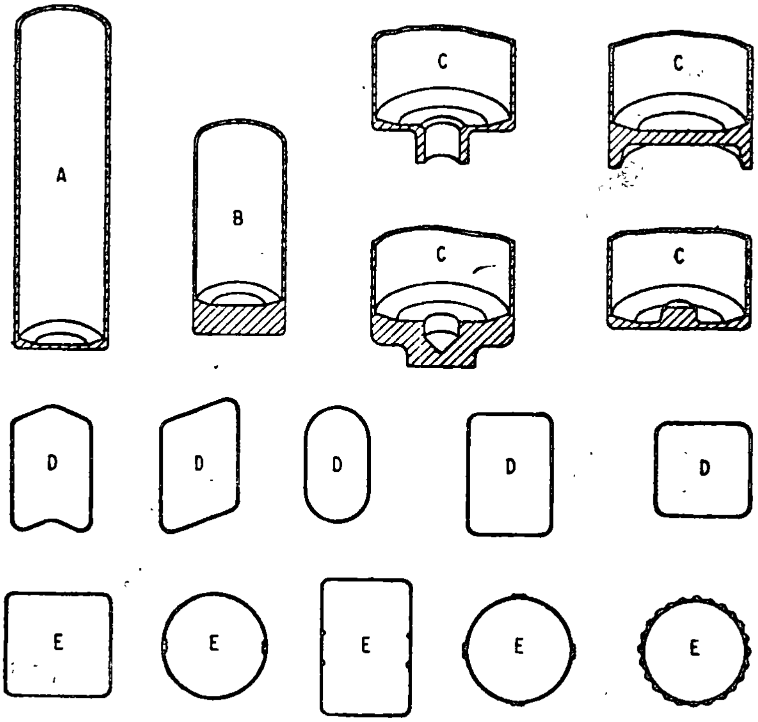


Fig. 52-12. Product shapes and proportions efficiently produced by cold impact extrusion.

②

Toward Better Extrusion Die Design

The forming of metal by pushing or pulling it through conical converging dies finds application in such processes as conventional extrusion, hydrostatic extrusion, and wire drawing.

The relatively recent development, hydrostatic extrusion, makes it possible to cold extrude many "difficult-to-form" materials, such as the high strength superalloys, and arc-cast tungsten and molydbenum. In this process, the metal billet, after being inserted into the die, is surrounded by a suitable liquid. The billet is then extruded by applying pressure to the liquid.

The semi-cone angle of the die (A in Fig. 1) has a pronounced effect on the total force needed to form a metal, the flow patterns, and the soundness of the extrusion. The effect of the semi-cone angle on the required drawing force is shown in Fig. 2. In the sound-flow region, the drawing stress changes continuously with the semi-cone angle, and reaches a minimum at the optimal semicone angle (A_o).

In hydrostatic extrusion, the optimal semicone angle is usually found by trial and error. However, a method has recently been developed to permit a more scientific choice of this cone angle.

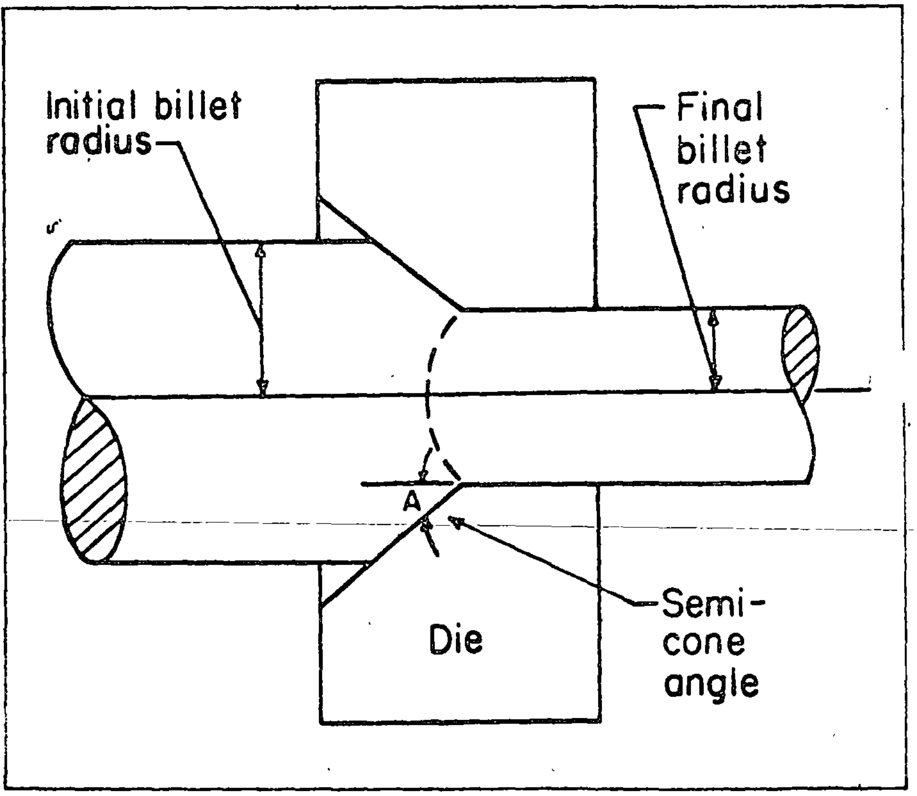


Fig. 1 Die and billet in drawing and extrusion.

Excessive cone angles may cause the metal to shear within itself and form its own cone angle that does not conform to the contour of the die. When this happens, the metal is said to have formed a "dead zone," and the new angle is known as the dead zone cone angle. For any semi-cone angle between A_1 and A_2, Fig. 2, this dead zone angle will form. The dead zone angle is constant for each percent of reduction, and the drawing force in this region remains constant. At semicone angles beyond A_2, the die acts like a cutting tool, since it shaves the billet. There is also a region overlapping the sound flow and dead zone regions where, when the right combination of reduction, friction, semicone angle, and prior straining are

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By William M. Evans and Betzalel Avitzur, Department of Metallurgy and Materials Science, Lehigh University, Bethlehem, Penna.

present, the material may undergo internal rupture forming defects called "central bursts."

Three interacting parameters—ideal deformation, shear resistance, and friction losses—vary with the die semicone angle, to produce a minimum on the total resistance curve, Fig. 3. Since the ideal deformation factor involves only the power required to reduce the diameter of the billet, it varies but little with change in the semicone angle. The shear resistance parameter is determined by the force needed to produce a specific amount of distortion, and increases as the semicone angle becomes larger. In drawing or hydraulic extrusion, the power losses due to friction come about as the billet passes over the die wall. With small semicone angles, the contact area between the die and billet is large, and therefore, the friction losses are large. As the angle becomes larger, the die-billet contact area and friction loss decrease. When the curves for all three of these effects are added to give the curve for total resistance, there is found, for any one set of friction and reduction conditions a minimum point at one particular semicone angle, the optimal semicone angle.

In order to determine the optimal

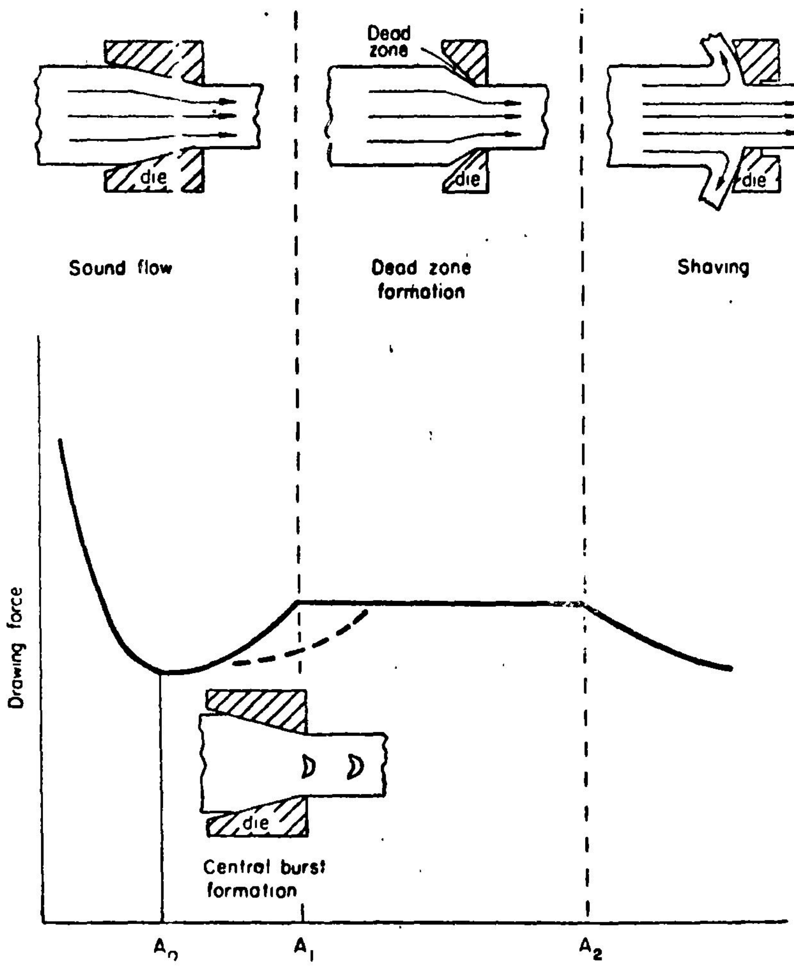

Fig. 2 Effect of semicone angle and mode of flow on drawing force.

semicone angle, all that is needed is a set of dies ranging from small to large semicone angle, and some means of measuring the force needed to extrude the material. The force can be measured with a set of calibrated strain gages mounted on the ram, or through calibration of a hydraulic pressure gage. Billets of various initial diameters are prepared. Extrusions are made over a range of semicone angles and reductions, and the force required is recorded for each combination of reduction and angle.

The curve for each reduction is then plotted for stress versus the semicone angle, Fig. 4. Since it is unlikely that any of the dies will have the angle which will produce the minimum stress, a curve is drawn connecting the minimums for each reduction and the value for the optimal semicone angle is read off the horizontal axis for each percentage of reduction. ●

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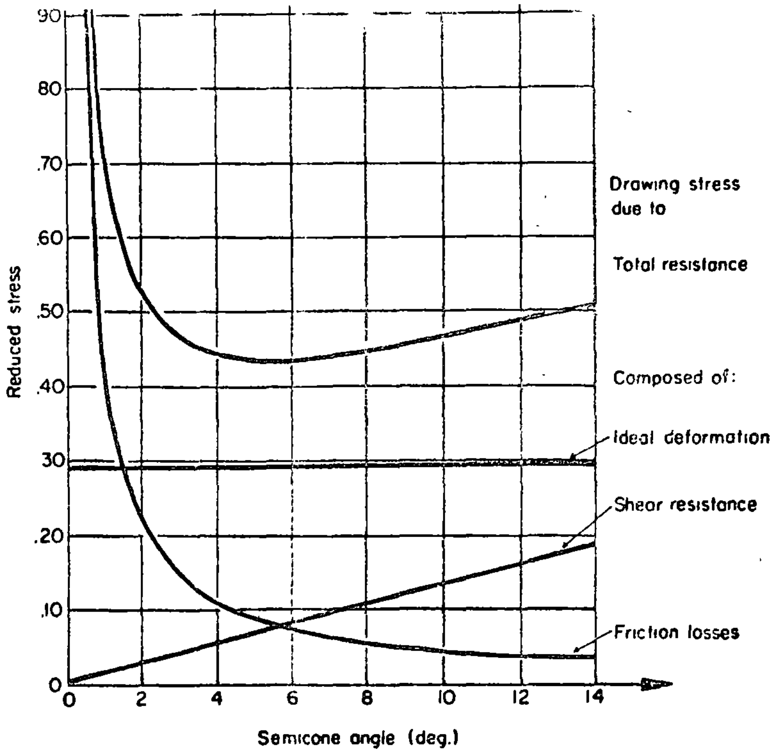


Fig. 3 Effect of change in semicone angle on drawing stress.

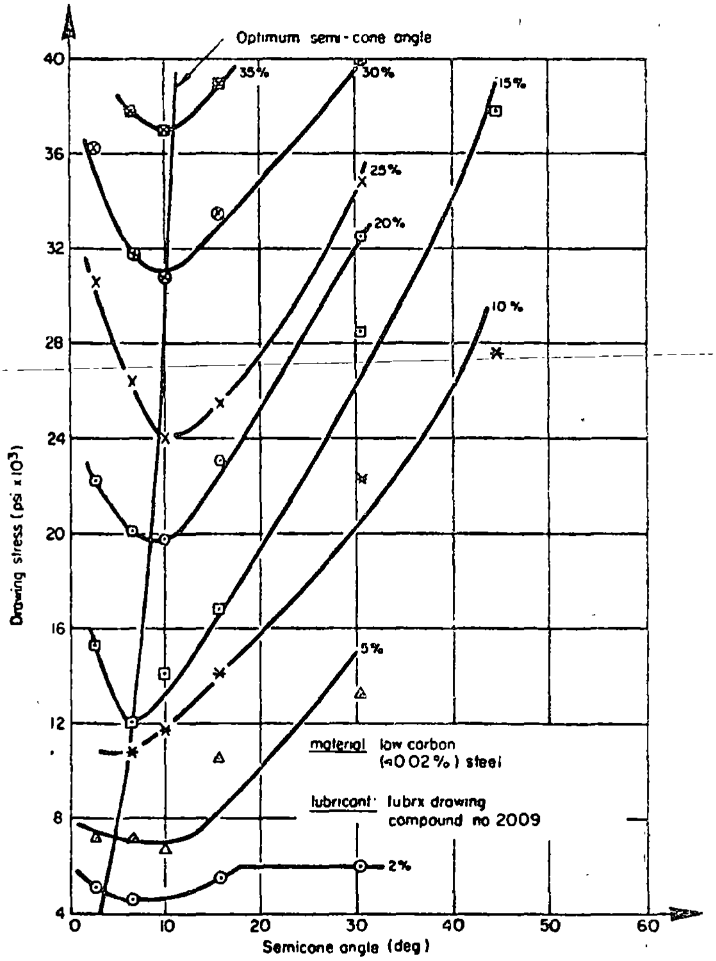


Fig. 4 Drawing stress vs. semicone angle and reduction.

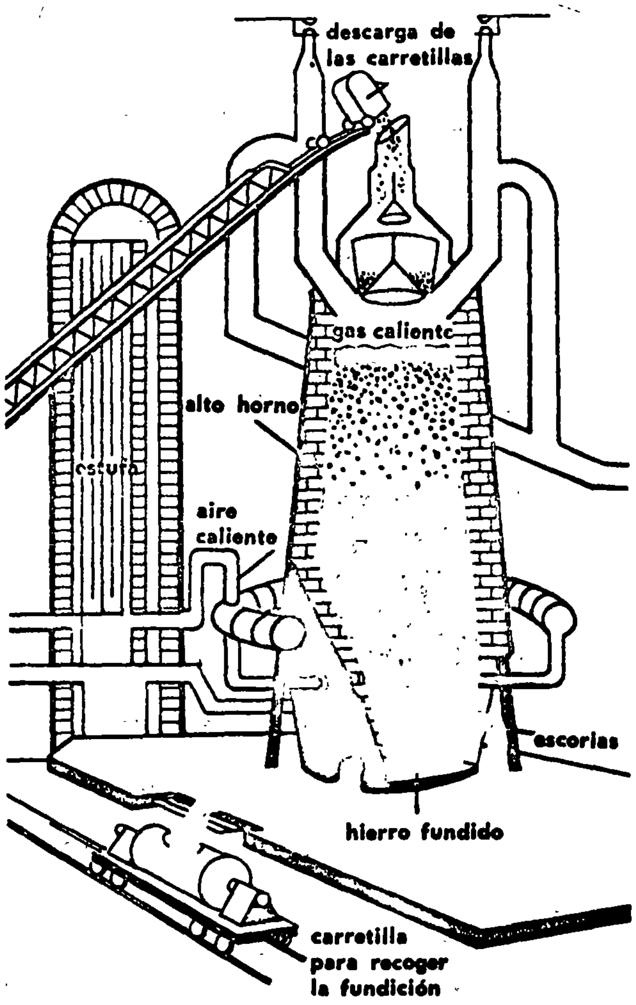
centro de educación continua
división de estudios superiores
facultad de ingeniería, unam

DISEÑO DE HERRAMENTAL

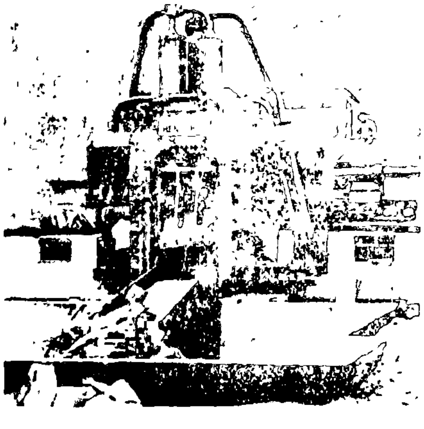
FUNDICION POR GRAVEDAD

ING. ULRICH SCHARER SAUBERLI

JUNIO, 1978.


descarga de las carretillas
gas caliente
alto horno
estufa
aire caliente
escorias
hierro fundido
carretilla para recoger la fundición

100% Precompression - the unrivalled feature of HENSCHEL Scrap Shears



It is astonishing how quickly the precompression operation is performed on Henschel scrap shears. The above pictures illustrate the speed at which for example a car body is precompressed.
The adjustable precompression wings are operated by most powerful hydraulic cylinders. Even car axles positioned at right angles to the wings are easily compressed. The precompression wings can be moved to be 2 metres apart from each other or approached to make full contact. Since the scrap falls in a precompressed condition into the feeder box, the walls of the latter suffer hardly any wear when the scrap is being pushed towards the knife.
The precompressing and cutting operations can be carried out independently of each other and therefore at the same time.

Other features of the successful Henschel shears are an extremely powerful hold-down gear and an unusually long stroke.

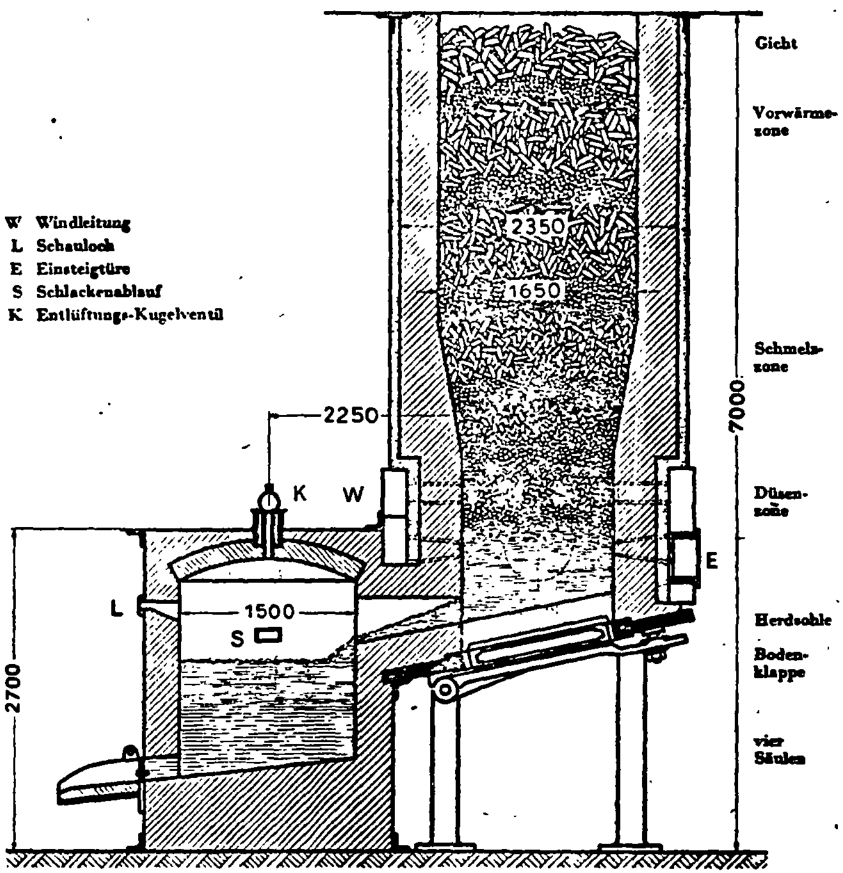


Abb. 22

Kupolofen mit Vorherd

FUNDICION CONTINUA DE HIERRO MEDIANTE INDUCCION

PONENCIA PROPUESTA POR SOCIEDAD ELECTROMECANICA, S. A. PARA EXPONERSE DURANTE EL "5o. CONGRESO NACIONAL DE LA INDUSTRIA DE LA FUNDICION", ORGANIZADO POR LA "SOCIEDAD MEXICANA DE FUNDIDORES".

Reporte del proceso y operación de una unidad experimental por R. S. Amala, J. B. Newsted de General Motors Corporation, Chevrolet Motor Division y W. J. Duca, ex-empleado de los Laboratorios de Investigación de General Motors y ahora empleado de Ajax Magnethermic Corporation.

Se ha demostrado la posibilidad de la fusión contínua de hierro gris por el proceso de inducción en un modelo experimental de diseño especial de horno de inducción sin núcleo en la fundición de hierro gris en la Chevrolet Saginaw. El concepto de este horno de fundición, desarrollado por los laboratorios de investigación de General Motors, está enfocado a combinar las mejores características de fusión por inducción eléctrica, especialmente las características de baja emisión de partículas y gases, con el flujo contínuo, y la gran capacidad de fusión de un horno de cubilote. En el concepto de fusión contínua de General Motors, la bobina de inducción está situada en posición horizontal en lugar de la posición vertical convencional, y la zona de fusión está llena de metal fundido todo el tiempo. Conforme la carga fría entra en uno de los extremos, el metal caliente es desplazado continuamente en el otro. Las ventajas son:

Por la alta velocidad de fusión, no es necesario disminuir la potencia eléctrica conectada durante la carga o el vaciado.

Una vida más larga del refractario en comparación con los hornos del tipo intermitente, ya que los refractarios permanecen a una temperatura uniforme y a esfuerzos de la misma intensidad porque no es necesario voltear el horno.

El diseño de una bobina horizontal permite el uso de densidados de potencia mucho más altas que en las unidades verticales sin núcelo, lo que reduce el tamaño del horno y la necesidad de contar con metal caliente.

Mediante el empleo de carga limpia y precalentada, el desprendimiento de gases y partículas es muy pequeño.

INTRODUCCION

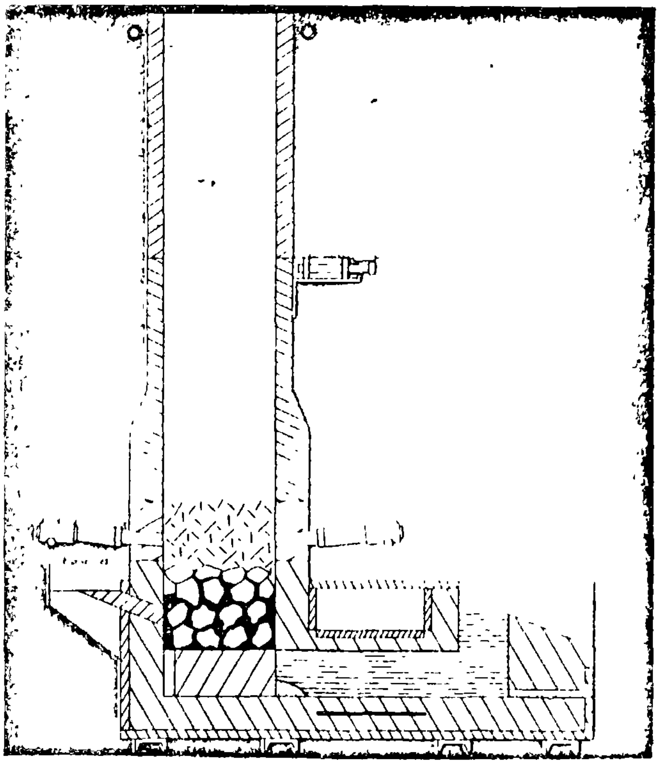
La búsqueda de un nuevo método de fusión de hierro gris, que se inició en los laboratorios de investigación de General Motors en Warren, Michigan, fué apresurado primordialmente por la necesidad creciente de mejorar las condiciones del ambiente en las cercanías de la fundición de hierro; como objetivo de esta investigación, se estableció el desarrollar un equipo de fusión eficiente para las fundiciones de hierro que disminuyeran las necesidades de equipo para el control de la contaminación del aire, y al mismo tiempo, el cumplir con las necesidades de las fundiciones automotrices para fundir muchas toneladas de hierro en una forma contínua.

Brevemente, este reporte se refiere a los esfuerzos hechos, tanto por los laboratorios de investigación de General Motors, así como de la División de motores de Chevrolet, en cooperación con Ajax Magnethermic Corporation para desarrollar y probar en el nuevo modelo piloto, el concepto de fusión contínua por inducción.

DESARROLLO DEL CONCEPTO DE FUSION CON POCOS DESPRENDIMIENTOS GASEOSOS.

En la búsqueda de equipo de fusión que generara pocos gases, se desarrollaron y evaluaron varios modelos de hornos en los laboratorios de investigación de General Motors.

Figura 1



La figura (1) muestra uno de estos modelos, el aparato de fusión por gas de inducción SIGMA (que son las iniciales de "Smokeless Induction Gas Melting Apparatus"), el cual combinaba una chimenea de fusión mediante gas natural con un sobrecalentador con núcleo dispuesto horizontalmente. La carga limpia se introdujo en la chimenea, fundiéndose a su paso a través de la sección de los quemadores, y fluyendo a través de una cama de carbón hasta el sobrecalentador. El desprendimiento de partículas desde este horno de fusión, fué mucho menor que los gases provenientes de un horno de cubilote, pero aún sobrepasaba la magnitud de los límites permitidos por las oficinas de control de contaminación de aire.

En el horno SIGMA, las pérdidas por oxidación eran altas y fué difícil obtener un nivel de carbón adecuado en el hierro con los blocks de carbón empleados en la cama.

El agregar a la carga más carbón en forma soluble, unicamente aumentó el desprendimiento de partículas. Si bien la chimenea vertical con calefacción por gas no tuvo éxito, el espacio receptor integral y horizontal por inducción tenía todas las características deseables de baja emisión de partículas inherente a la fusión por inducción, y con algunas modificaciones, parecía tener un potencial considerable como una unidad de fusión.

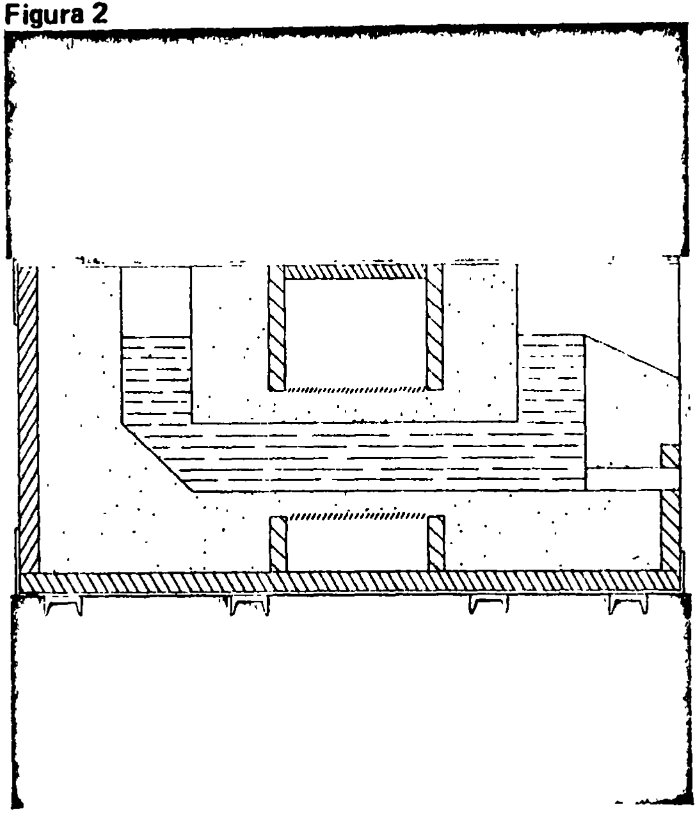
A través de mas trabajo se desarrolló, un horno a escala de laboratorio que finalmente fué capaz de fundir continuamente 400 Lbs. de hierro por hora. Esto proporcionó el concepto del diseño básico para el horno de inducción horizontal contínuo conocido como HCIF (que son las iniciales de Horizontal Continuous Induction Furnace, U. S. patent 3,483,301).

El modelo del laboratorio HCIF, mostrado esquematicamente, y en operación en la figura (2), muestra un diseño relativamente simple consistiendo de un tunel horizontal con la bobina de inducción alrededor de este.

Una columna vertical de metal en cada extremo del tunel formaba las áreas de carga y vaciado, mientras que la posición del pico de descarga controlaba el nivel del metal.

Esta unidad operó mediante un suministro de corriente con el que ya se contaba en los laboratorios de investigación de General Motors de 190 kw a 960 Hertz, el horno sirvió como un modelo a un programa de computadoras con el cual fué posible predecir las características de diseño y operación de unidades más grandes. Una característica singular del diseño HCIF era su capacidad para operar a una intensidad de potencia mucho más alta que los hornos de inducción verticales de tamaño similar. La densidad de potencia es la expresión de la potencia de la bobina por la unidad de la superficie lateral del metal contenido dentro de la bobina. Los hornos de inducción verticales normalmente están limitados a una densidad de potencia entre 200 y 300 watts/plg2, porque la presión electromagnética a niveles de potencia más altos aumenta el menisco y puede provocar la separación del metal fundido de la pared del horno. (Efecto de "Pellizco" Electromagnético).

Figura 2



Los "pellizcos" excesivos aumentan no solamente la velocidad de oxidación de la carga sino que van acompañados del aumento de erosión del recubrimiento del horno en el área donde ocurre el "pellizco" debido al atrapamiento de aire o escoria en esa área.

UNDICION ONTINUA DE HIERRO EDIANTE INDUCCION

modelo HCIF las columnas verticales de metal proporcionaban la presión ferrostática suficiente primir el efecto de este "pellizco" permitiendo la operación de la unidad de laboratorio con una ad de potencia de 850 watts/plg2. La altura necesaria de la columna ferrostática es un función de la densidad de potencia como de la frecuencia del sistema de alimentación eléctrica.

odelo de laboratorio HCIF durante varios meses se efectuó como una unidad y demostró que los niveles de desprendimiento de gases fueron bajos y que era posible lograr la contínua. La inspección del horno durante esa etapa, demostró que se habían presentado muy daños en el recubrimiento refractario. Esta unidad no admite facilmente la carga de materiales de nsidad tales como el carbón y el silicio, pero las ventajas demostradas en el programa de orio garantizaban un mejor desempeño con un horno de dimensiones mayores.

strucción de un modelo piloto HCIF con una capacidad de fusión de 2 a 4 toneladas por hora, está ada a la división de motores de Chevrolet en cooperación con los laboratorios de investigación de al Motors para verificar las pruebas de laboratorio y para evaluar las consideraciones prácticas de La unidad experimental se puso en operación en fundición de hierro gris de Chevrolet en Saginaw.

ILOTO HCIF EN CHEVROLET

escala piloto, fué diseñado y construído para la Chevrolet por Ajax Magnethermic ation en Warren, Ohio, usando como base la información para el diseño proporcionado por la tadora, además del concepto desarrollado por los laboratorios de investigación de General Motors. nidad estaba diseñada para fundir 4 toneladas por hora con un suministro de corriente de 2,000 atts a 60 hertz y se proyectó para contener aproximadamente 12 toneladas de metal fundido. Para grama piloto con el modelo HCIF, la Chevrolet proporcionó un sistema de carga contínua con un

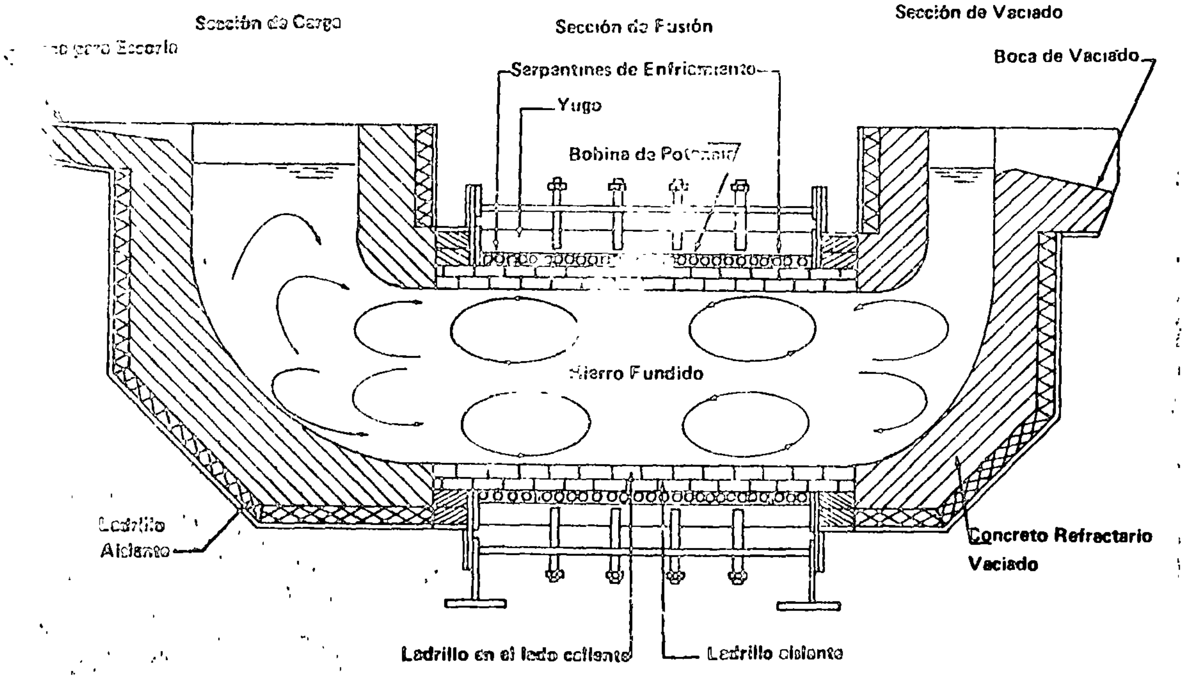
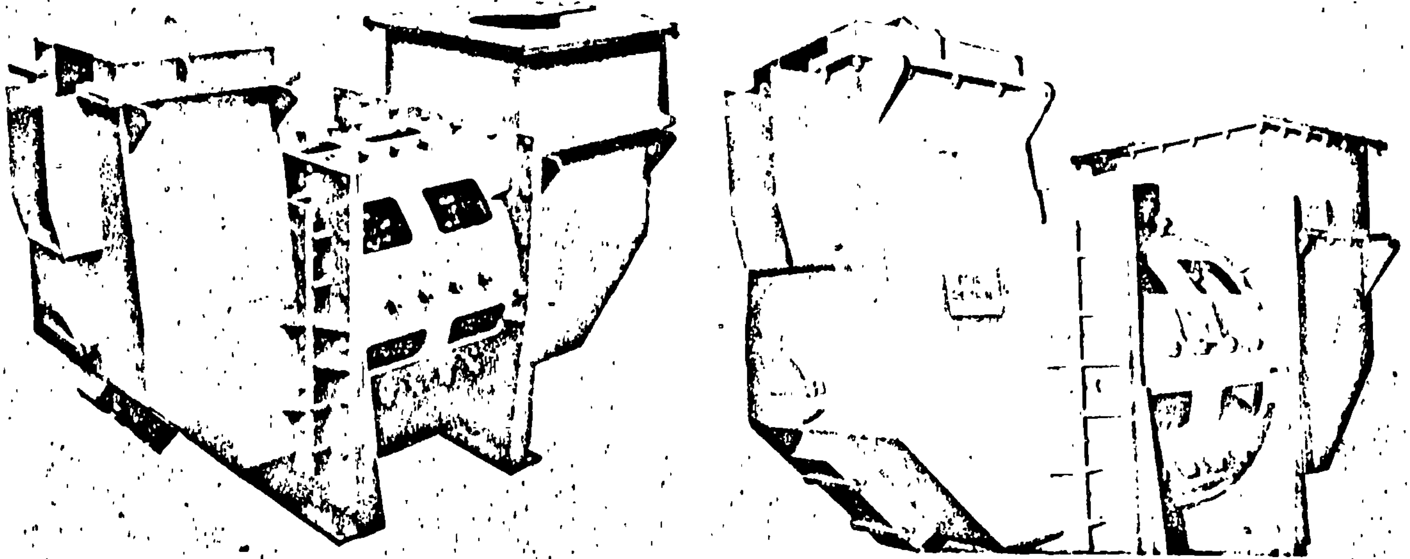


Figura 3

Sección del Horno Contínuo de Fusión HCIF secador rotatorio así como depósitos de almacenamiento y alimentadores adecuados, un inyector de carbón y un horno receptor del tipo canal de 3 toneladas según el diseño convencional de Ajax. Este equipo se instaló junto a un horno de cubilote existente para permitir el empleo de la capacidad de producción relativamente pequeña del horno de inducción en una línea de vaciado convencional.

El modelo a escala piloto HCIF se construyó en 3 secciones; un extremo de carga, un extremo de descarga, y la sección de potencia, tal como se muestra en la figura (3). El horno es de 15 piés 2 pulgadas de largo, por 8 piés 6 pulgadas de altura, por 6 piés 5 pulgadas de ancho y tiene una bobina de 40 pulgadas de diámetro interior, un diámetro dentro del refractario de 28 pulgadas y la sección de potencia de 5 piés 4 pulgadas de largo. Las 2 secciones extremas del horno están recubiertas con un refractario del tipo vaciado de alta alumina. La sección de potencia tiene 2 hileras de ladrillo de alta alumina junto con ladrillos de mullite. Las 3 secciones están unidas mediante bridas atornilladas y soportadas en la sección de potencia sobre una cimentación de concreto. La parte superior de la sección de carga, es desmontable para permitir el ajuste de la altura de la columna ferrostática. Se cuenta con tapones localizados en los dos extremos para vaciar el horno, puesto que no hay necesidad ni se cuenta con facilidad para voltear el horno. La sección posterior o de carga cuenta también con una pared inclinada para facilitar la eliminación de escoria y la inyección de carbón.



En abril 21 de 1969, el modelo HCIF se cargó con hierro fundido del grado de cilindros (equivalente a 4.3 de carbón) proveniente de las instalaciones para la fusión de la producción normal de Chevrolet. Después de la inspección rutinaria y de las pruebas de potencia, se elevó el nivel del metal hasta la altura de la boca de descarga lo que estableció una presión ferrostática de aproximadamente 21 pulgadas. La operación del horno fué entonces relativamente simple, los materiales de la carga se alimentaron continuamente en la sección posterior del horno desplazándose una cantidad igual de metal fundido en la boca de descarga pasando el metal fundido al horno receptor del tipo canal. Las temperaturas en el baño y en la descarga dependieron entonces del balance entre la velocidad de carga y la potencia para la fusión. Cuando no se estaba fundiendo, fueron necesarios 350 kilowatts para mantener a 2,700º F (1482ºC) las 12 ó 13 toneladas de metal contenidas en el horno HCIF.

MATERIALES DE CARGA

Uno de los principales objetivos del programa de pruebas en el horno HCIF, era la determinación del tipo de materiales de carga que podía admitir un horno de este tipo. El horno secador con calefacción por gas del tipo rotatorio, así como el diámetro del horno limitaron la cantidad y la naturaleza de la carga que podría alimentarse continuamente al horno. Dentro de esta limitación, no se encontró ninguna dificultad en la fusión de desperdicio de hierro vaciado de la fundición sólo o hasta con 30% de chatarra de acero. Cuando se tenía acero en la carga, se añadió silicio y manganeso en los carros pesadores durante la adición de carga. Las adiciones de carbón tendieron a flotar cuando se añadieron separadamente al baño fundido debido a su baja densidad y a la ausencia de agitación en la superficie de la zona de carga debida a la columna ferrostática. Se obtuvo el control del carbón mediante la inyección de carbón granulado. (grado de recarburación de malla 60) aproximadamente 18 pulgadas abajo de la superficie del metal utilizándose una lanza de grafito y gas nitrógeno como vehículo, con una eficiencia de inyección de carbón del 55% entre 2 ó 3 libras de carbón por minuto para recarburizar una carga con 30% de acero. El carbón no disuelto se acumuló en la superficie del metal y en la zona posterior del horno. La capa de carbón que se formó durante la inyección resulto ser beneficiosa en el sentido de que las salpicaduras asociadas con la carga se disminuyeron notablemente, y se evitó la adherencia de escoria y salpicadura a las paredes laterales de la zona de carga, lo que redujo las tendencias al puenteo. También fué mucho más fácil escoriar el horno ya que la escoria tendió a formar una capa dura que se retira facilmente. La capa de carbón también actuó como un aislador y redujo la pérdida de carbón en el metal durante los períodos de retención. Es impráctico el añadir rebaba suelta de hierro vaciado, brinquetas u otros materiales similares de carga directamente al horno HCIF. Tal tipo de carga, de baja densidad, flota en la superficie y provoca el puenteo cuando se permite su acumulación. Las brinquetas de hierro vaciado prensadas en caliente, también flotan de tal modo que aparentemente se puede concluir que los materiales con una densidad menor que la del hierro líquido no pueden utilizarse en cantidades significantes, a menos que se pueda desarrollar un método de alimentación forzada.

CARACTERISTICAS DE OPERACION

En las pruebas de fusión contínua de larga duración en Chevrolet, el horno piloto HCIF ha fundido más de 50 toneladas por día a una velocidad de 3.1 tonelada por hora con una temperatura de vaciado de 2,700ºF. En general, en esas pruebas se cargaron rechazos sin limpiar provenientes de la fundición a aproximadamente 300ºF (148ºC). El consumo promedio de potencia durante la fusión contínua fué de 565 Kw-Hora por tonelada. Son de esperarse consumos menores de corriente por tonelada cuando se emplean unidades de fusión HCIF más grandes.

Un problema que se encontró durante las campañas de fusión, fué la pérdida parcial de potencia debida a la acumulación de escoria en el recubrimiento horizontal de la sección de potencia del horno. Los cambios en las características eléctricas del HCIF, indicaron que la escoria se acumula como un resultado de la agitación electromagnética o el "Pellizco" magnético, como se ilustra en la figura (3). Esto sucede cuando se permite que la temperatura de operación baje excesivamente.

FUNDICION CONTINUA DE HIERRO MEDIANTE INDUCCION

El mantener una temperatura de operación alta en el baño, (2,700°F, 1510°C y más alta), causa una reducción química de la acumulación de escoria por el carbón en el hierro, lo cual va acompañado de generación de monóxido de carbón. Una vez que esta escoria acumulada se reduce, se vuelve a obtener la posibilidad de emplear potencia plena. La utilización de materiales de carga limpios así como el aumento de la altura de la columna ferrostática, también ayuda a disminuir la acumulación de escoria.

CONTROL DE LA COMPOSICION

Por ejemplo, un carbón equivalente de 4.3 se ha logrado en el horno HCIF durante campañas de fusión prolongada, según se determina mediante análisis químicos periódicos, así como pruebas de enfriamiento. Se ha demostrado la posibilidad de la inyección del carbón, pero como se anotó previamente, es de desearse algún refinamiento en las técnicas de inyección. Las fluctuaciones en la composición química son bajas probablemente debido a la gran reserva de metal siempre presente en el horno HCIF. Las pérdidas de material de aleación también son muy bajas en esta unidad como lo son en otras formas de fusión por inducción.

Los estudios acerca de la duración del refractario están incompletos en la unidad piloto HCIF, puesto que el horno aún trabaja con el recubrimiento original.

Más de 1,300 toneladas se han fundido en la unidad con el recubrimiento inicial durante los primeros 8 1/2 meses de operación contínua. Puesto que el horno no se voltea y permanece lleno de metal, es de notarse la ausencia de daños en el refractario debido a esfuerzos térmicos o mecánicos. 7

El desgaste del refractario debido a una naturaleza química, se evaluará cuando se vacíe el horno. Se previó un aumento en el consumo de corriente del horno HCIF, puesto que ocurrió la erosión del refractario debido a la disminuación de la distancia entre la bobina y la carga.

Ha ocurrido lo opuesto, es decir, el consumo de potencia disminuyó ligeramente al principio de la campaña de 8 1/2 meses probablemente debido a que la escoria en la sección de potencia había disminuído la distancia de acoplamiento. Desde esa vez, se han mantenido relativamente constantes excepto cuando la temperatura ha sido demasiado baja y cuando se presentan las acumulaciones periódicas discutidas previamente.

SUMARIO

La operación de la unidad piloto HCIF en la fundición de hierro gris en la Chevrolet durante los pasados 8 meses, ha suministrado una evaluación realística de las ventajas y desventajas de este concepto de fusión. En este momento, la hoja de balance para el horno HCIF muestra:

VENTAJAS

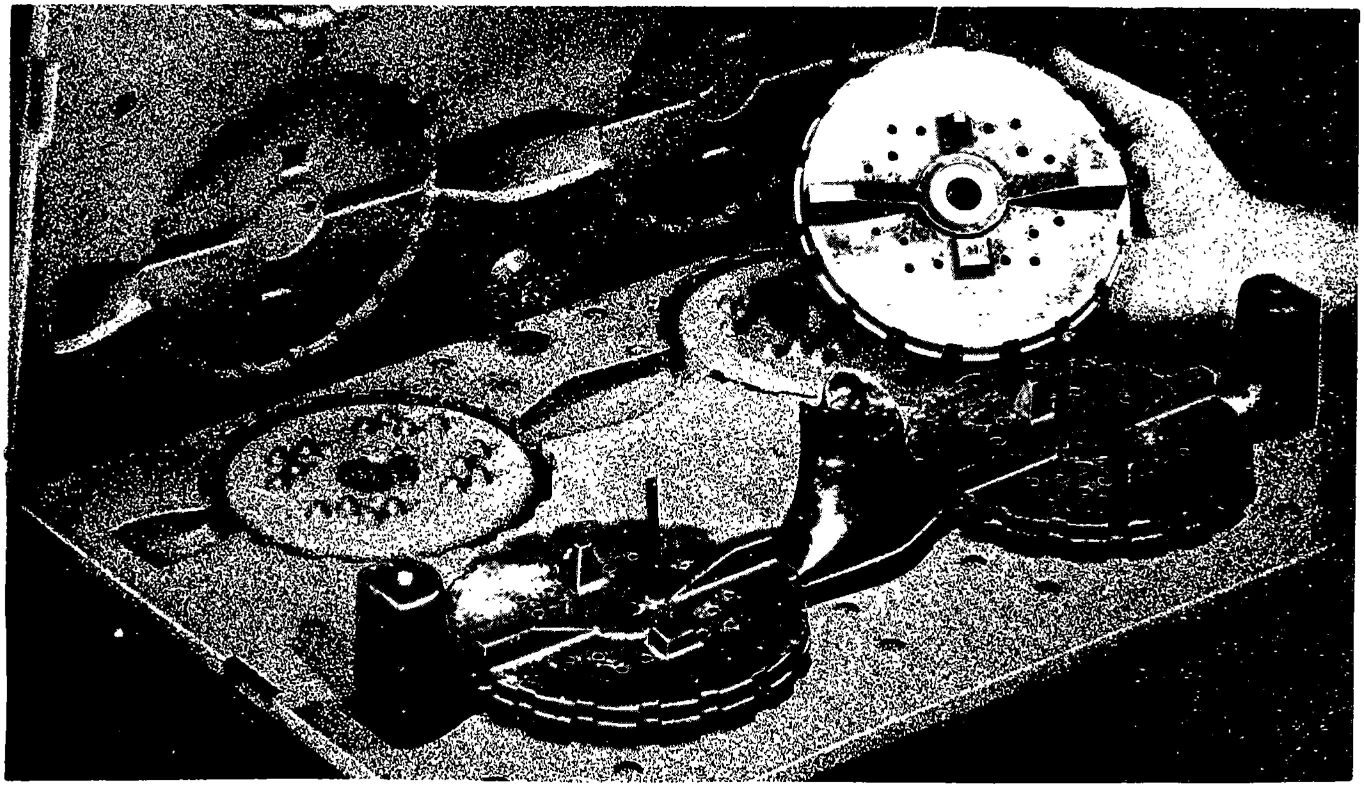
1.- Capacidad para fundir continuamente con baja emisión de gases.
2.- El potencial para una durabilidad excepcionalmente larga del refractario.
3.- Reducción en el tamaño del horno debido a la alta densidad de potencia.
4.- La capacidad de iniciar y suspender la operación del horno rapidamente.
5.- La utilización óptima de la potencia durante el tiempo de fusión. No hay períodos ociosos.
6.- Su adaptabilidad para un control totalmente automático.
7.- Baja oxidación y pérdidas y un recuperamiento máximo de aleaciones.

DESVENTAJAS

1.- Las cargas de baja densidad no se funden rapidamente.
2.- Es necesario mantener un suministro de metal fundido.
3.- Es necesario emplear cargas secas. Es de desearse contar con cargas limpias.

El horno horizontal de inducción ha demostrado ser tecnicamente factible en pruebas de producción piloto, pero las ventajas económicas en relación con otros procesos de fusión, aún quedan por determinarse.

Shell Molded Parts



EL MODELADO

La fundición es un procedimiento de fabricación de piezas metálicas que consiste en verter el metal en fusión en moldes refractarios, cuya forma conserva al enfriarse.

El recinto hueco se vierte el metal líquido se llama MOLDE y su confección MOLDEO.

Los moldes se realizan en ARENA PISONADA alrededor del MODELO colocado dentro de las CAJAS DE MOLDEO.

Observación.- Para ciertos metales de punto de fusión poco elevado, se emplean moldes metálicos, llamados también COQUILLAS. El empleo de estos moldes suprime la operación de moldeo y por lo tanto el modelo. Nos limitamos por ello a la simple mención de esta técnica ajena al trabajo de modelista.

El relleno del modelo se le llama COLADA.

La extracción de la misma, después de solificada, se efectúa deshaciendo el molde, y se llama DESMOLDEO.

ARENAS DE FUNDICION

Las arenas de fundición, ó para moldeo, han de cumplir las siguientes condiciones:

Ser INFUSIBLES, para resistir elevadas temperaturas. La sílice, que debe entrar en proporción de 75% a 90%, les adjudica esta propiedad.

Ser PLASTICAS para adaptarse a la forma de los modelos.

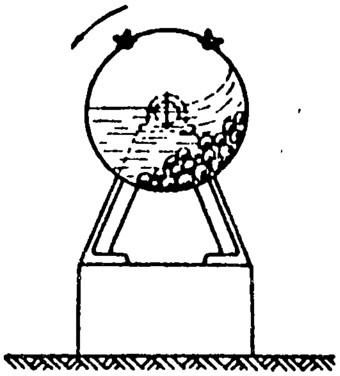


FIG. 64. — Mezclador de tambor y bolas de sílice para dispersar el negro.

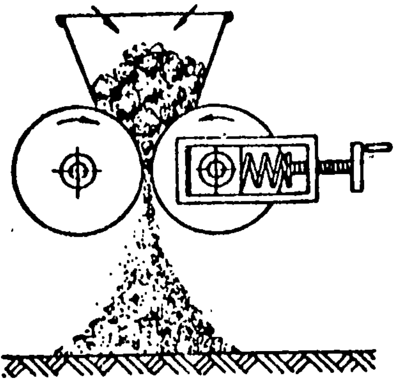


FIG. 65. — Desterronador de cilindros: los dos cilindros no llegan nunca a tocarse. Uno de los dos va montado en soportes corredizos y puede alejarse elásticamente para dejar paso a trozos de metal, guijarros y similares.

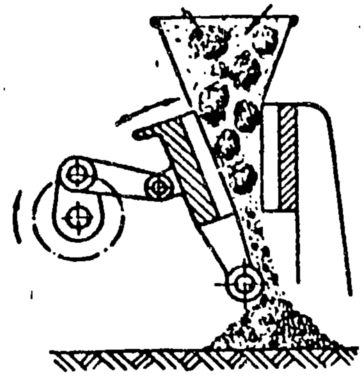


FIG. 66. — Matracadora de mandíbulas.

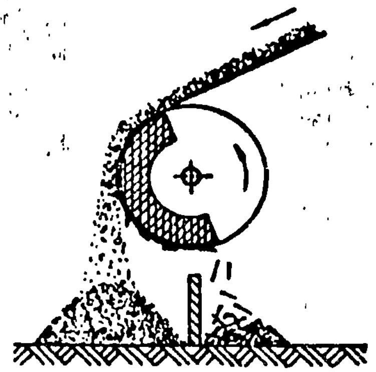


FIG. 67. — Separador magnético de las partículas de hierro. Estas quedan adheridas al tambor giratorio mientras permanece en contacto con el imán (permanente o electromagnético) que está fijo. Luego caen al otro lado de la pared.

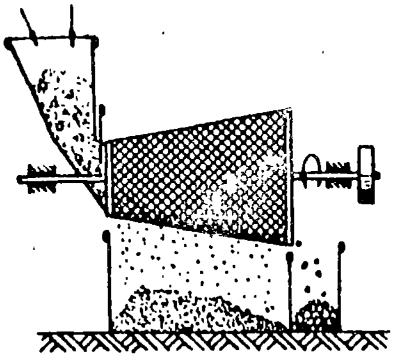


FIG. 68. — Criba giratoria. Una tolva unida a la criba regula la producción. Colocando telas metálicas crecientes desde la tolva a la descarga se puede seleccionar la arena de diverso grosor de grano.

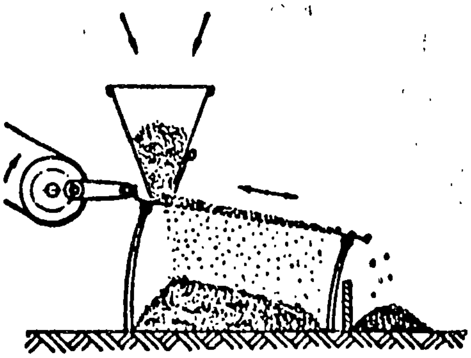
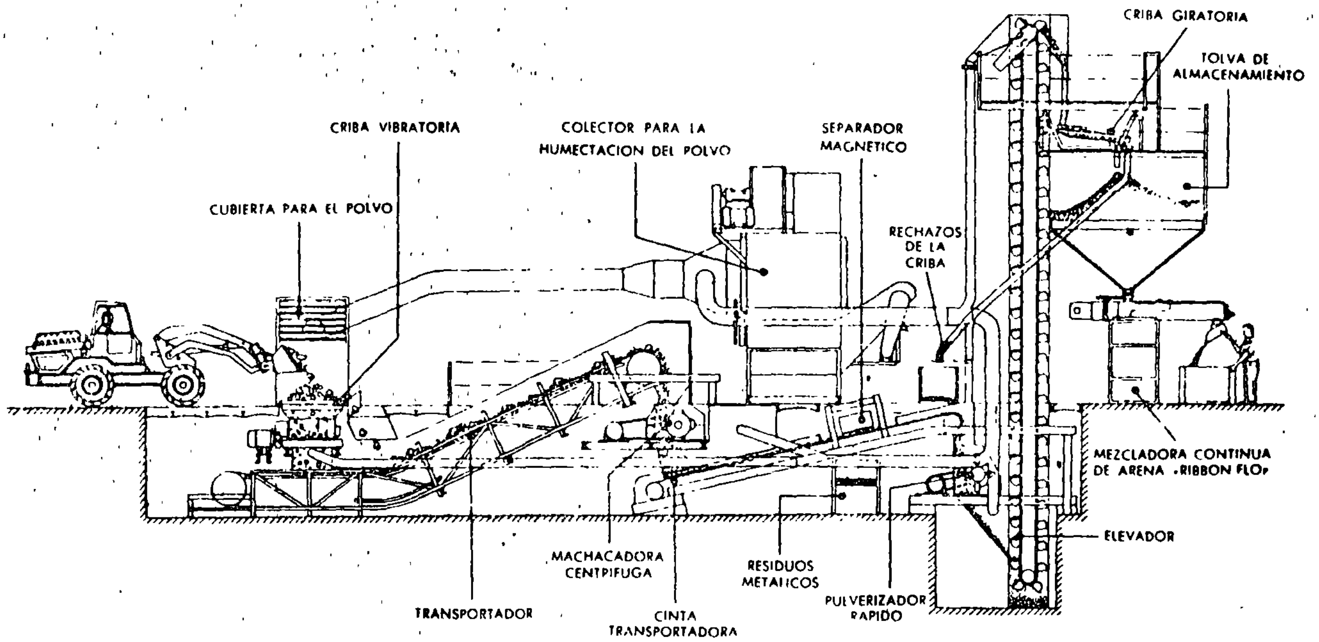


FIG. 69. — Criba de sacudidas. Una tolva inmediata a la criba regula la alimentación. En esta criba, análogamente, se pueden escalonar las telas metálicas o chapas perforadas para seleccionar el grosor de las arenas.

Recuperación de la arena silícea de los moldes furánicos

La Foundry Machinery Division de la Baker Perkins Ltd., de Peterborough, Inglaterra, ha creado una planta que recupera, sin incineración, del 90 al 95 % de la costosa arena de sílice, contenida en los moldes de arena furánica usados. Con este tipo de planta (véase croquis adjunto), pueden recuperarse hasta 10 t de arena por hora. No hay motivo alguno que impida rebasar esta cantidad mediante la modificación de las etapas básicas, que comprenden una serie de máquinas machacadoras, graduadoras y elevadoras. Cuando el ritmo de recuperación sea moderado —por ejemplo, 20 t diarias—, se puede suministrar una planta más pequeña, pero fundamentalmente idéntica. Partiendo de los precios vigentes de la arena de sílice en el mercado mundial, puede esperarse una pronta amortización del capital invertido.

Se procede a romper los moldes usados, pasando los pedazos por una criba vibrante a un transportador de tablillas de acero que los lleva a una machacadora centrífuga, donde los trozos más grandes quedan reducidos a 16 cm^3. A continuación, una cinta de caucho los transporta debajo de un separador magnético que extrae los residuos metálicos. Después se alimenta la arena a otra trituradora que la reduce a estado granular, pasando luego a la base de un elevador de cangilones que la asciende para alimentarla a una criba graduadora con aberturas de 420 micras. La arena tamizada cae en una tolva de almacenamiento y la rechazada va nuevamente a la sección trituradora. El polvo y la arenilla se quitan por medio de extractores situados en los cuatro puntos siguientes: la criba vibrante, la machacadora centrífuga, la trituradora y el elevador de cangilón.



Para el tratamiento de la arena refinada se utiliza la mezcladora de arena «Ribbon-Flo», máquina creada para mezclar continuamente la arena con los aglutinantes y los catalizadores (ambos pueden usarse en polvo y en estado líquido) y hacer pasar la mezcla resultante a ritmos hasta de 10 t/h a la caja del molde o del macho.

La arena se alimenta desde una tolva situada encima de la máquina a una cuba en forma de «U», que está montada en el mueble donde se encuentran los mandos y equipo eléctrico. La arena se mezcla con los otros ingredientes por medio de una paleta patentada, accionada a una velocidad constante en el interior de la cuba. Los aglutinantes y catalizadores se bombean desde tambores de almacenamiento a la mezcladora, pasando por una manguera de plástico. Es posible ajustar con toda precisión la velocidad de cada bomba, con objeto de mezclar el catalizador y el aglutinante en cualquier proporción, hasta un máximo de 9:1.

La arena tratada se distribuye entre las cajas de los moldes mediante una canaleta pequeña de ajuste manual, instalada en un extremo de la cuba mezcladora. Se puede girar la cuba 360° y es posible variar el ángulo de descarga a fin de suministrar la arena a cualquier punto, dentro de un radio de 60 cm. De este modo se reduce al mínimo el apisonado manual cuando se llenan las cajas grandes. Mediante el montaje de la «Ribbon-Flo», en una plataforma giratoria, la máquina completa puede girar 180°. Otros aglutinantes químicos, como silicato sódico y aceites de fraguado al aire, pueden mezclarse separadamente o al mismo tiempo en estas máquinas.

Han de tener COHESION, ó aptitud para conservar las formas que se les dé. Esta propiedad la adquieren incorporándoles de un 5% a 15% de arcilla y 8% de agua.

PERMEABILIDAD.- Que es la aptitud para la evacuación de los gases desprendidos durante la colada. La permeabilidad depende del grosor de los granos, pero también de la compresión de la arena. Se mejora incorporándole hulla pulverizada.

La arena rica en arcilla se llama GRASA ó FUERTE: Es plástica y poco permeable. Por el contrario la ARENA MAGRA, más rica en sílice, tiene poca cohesión.

La arena es húmeda. Se dice que esta VERDE cuando no se ha secado antes de la colada, y cuando se ha desecado en una estufa, se le llama ESTUFADA.

OBSERVACION.- En realidad las arenas que han de secarse en estufa, tienen una composición algo distinta a la de las arenas verdes que se moldean sin desecación previa.

Para proteger al metal contra la acción de la arena se emplea un aislante de (negro vegetal), constituido por carbón vegetal pulverizado desleído en agua, con el que se embadurna el molde.

Este aislante favorece el desprendimiento de las piezas de fundición y la mejor penetración del metal líquido en los rincones.

La ARENA PARA NOYOS, que debe de ser muy porosa y friable, es una arena magra. Muy rica en sílice, se liga con dextrina ó melaza. Se deseca siempre en estufa.

ELEMENTOS NECESARIOS PARA EL MOLDEADOR

El material necesario para el moldeador, comprende sus herramientas individuales y los útiles adecuados para la fundición.

LAS HERRAMIENTAS INDIVIDUALES DEL MOLDEADOR.- Son las siguientes: La PALA, La LLANA, para el manejo de la arena; el PALETON, El ATACADOR, y el PISON, para comprimir la arena; la ESPATULA, el CORCHETE, la ESE, la GUBIA, ó cucharilla, los ALISADORES, para retocar las improntas y ángulos; la REGLA y la TABLA ó TABLETO DE MOLDEAR, las AGUJAS largas y finas para consolidar la arena en los lugares delicados; los PIQUETES (varillas) que se hincan en el modelo y sirven para retirarlo del molde.

LOS UTILES DE LA FUNDICION.- Son: Las cajas, marcos y chasis, formados por bastidores, generalmente de fundición, que sirven para contener la arena del molde, facilitando su manipulación. Los cuadros ó cajas son casi siempre cuadrados ó rectangulares y algunas veces redondos.

Las cajas se componen de dos marcos, el superior y el inferior, y a veces una ó más partes intermedias llamadas CHAPAS, CAPAS ó simplemente marcos intermedios. Van reforzados por nervios y orejas, por las que pasan clavijas o pasadores que permiten el ajuste perfecto de las diferentes partes del molde. Unas asas o pomos facilitan su manejo.

El marco sin orejas representa un modelo de cajas sin orejas que se emplea utilizando pasadores de carrete que se colocan en la arena al confeccionar el --

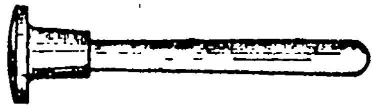


Fig. 68. — Pisón.

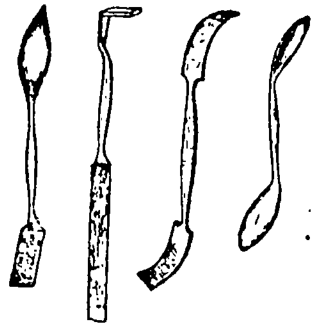


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Fig. 69. — Espátula.
Fig. 70. — Corchete.
Fig. 71. — Esc.
Fig. 72. — Gubia.

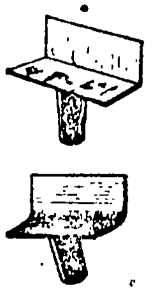

Fig. 73.
Alisadores.

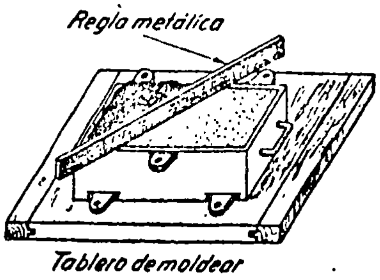

Fig. 74.
Regla y tablero de moldear.

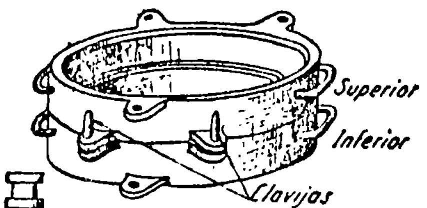

Fig. 76.
Caja redonda.

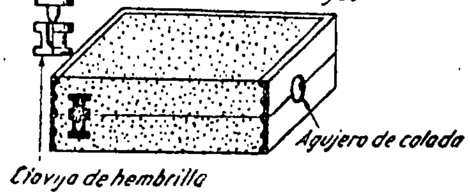

Fig. 77.
Marco sin orejas.

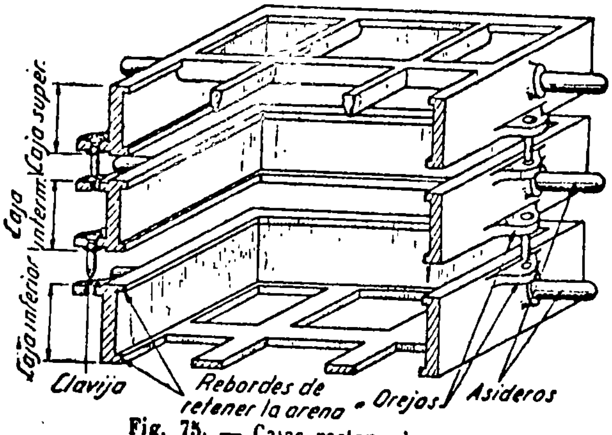

Fig. 75. — Cajas rectangulares.

molde. Esta disposición permite también el empleo de marcos de orejas ocultas ó embutidas.

Los marcos deben de existir en número suficiente y de diversas dimensiones. Representan una parte muy importante del material de fundición.

MOLDEO A MANO

Por medio de algunos ejemplos indicaremos en qué consiste el trabajo del moldeador, el cometido del modelo y su influencia en la confección del molde.

El molde se establece en tantas partes como sea necesario para permitir la salida ó extracción del modelo.

La superficie de separación de las diferentes partes se llama JUNTA. La disposición de las Juntas, su forma y su superficie, depende de la forma de la pieza que se ha de fundir.

Observación.- Cada una de las partes del molde puede estar constituída por uno ó varios marcos, según la altura de la pieza que se ha de moldear. En este caso los diferentes marcos que componen una parte se enlazan entre sí formando un bloque. Este enlace se efectúa por medio de pasadores ó pernos que atraviesan las orejas, chavetas transversales que atraviesan los pernos, ó bien con simples cintas metálicas sujetas a las asas.

Examinaremos el moldeo ordinario, con o sin falsa división, el moldeo con noyo, el moldeo con chapa y el moldeo con terraja.

MOLDEO ORDINARIO SIN FALSA MITAD

Este es el caso más sencillo que se puede pre-

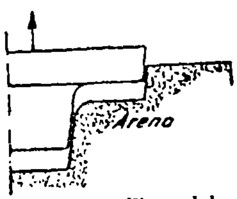

Fig. 83. — El modelo con «salida» cesa de estar en contacto con su impresión sobre la arena desde el principio de su extracción.

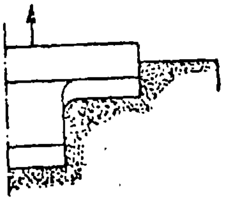

Fig. 84. — El modelo sin «salida» conserva el contacto con la arena en todo el recorrido de su extracción.

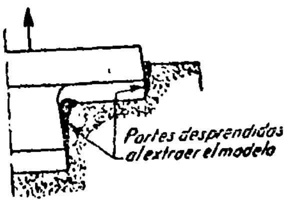

Fig. 85.
El modelo con «contra-salida» arrastra la arena.

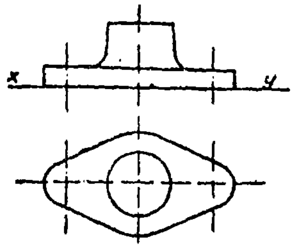

Fig. 78.

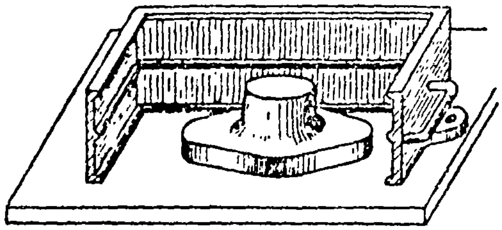

Fig. 79. — El modelo y el marco se colocan sobre la tabla de moldear.

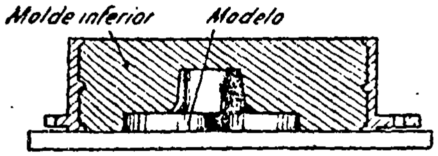

Fig. 80. — Marco inferior relleno.

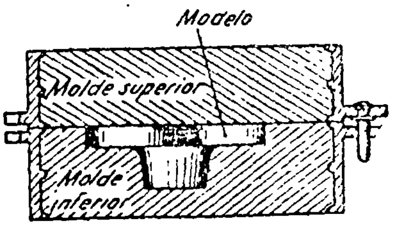

Fig. 81. — Marco inferior invertido y marco superior relleno.

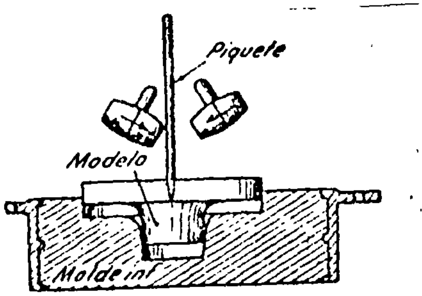

Fig. 82. — El modelo se desprende y se separa del molde.

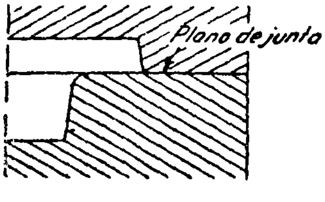

Fig. 86. — La posición de la junta depende de la distribución de la salida.

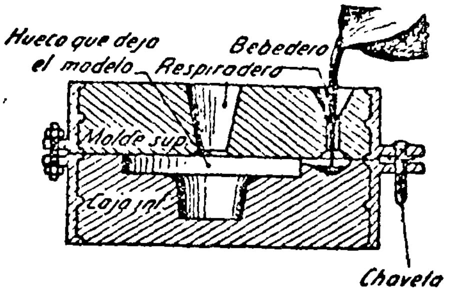

Fig. 87. — El molde terminado recibe el metal fundido.

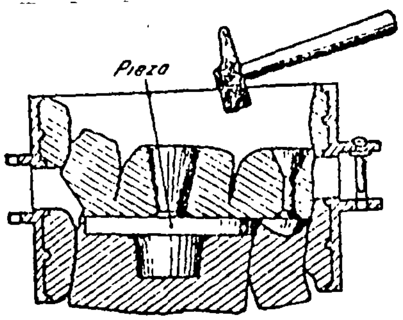

Fig. 88. — Cuando el metal se enfría, el molde se despedaza.

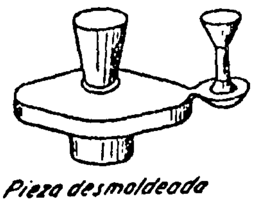

Fig. 89. — La pieza al salir del molde.

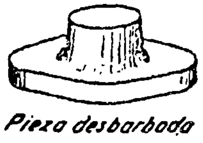

Fig. 90.
La pieza terminada.

sentar en el moldeo. La junta pasará por la superficie plana.

La disposición del modelo y del marco que constituirán la parte inferior del molde en la tabla de moldear. La superficie de esta última, materializa la junta de moldeo. El marco empleado no lleva pasadores.

La arena colocada en el marco se comprime con regularidad alrededor del modelo. Esta operación se denomina rellenado de la parte inferior, o sea la caja ó -- marco que queda debajo.

Se invierte esta parte, con lò que la junta queda al aire; se la aisla con arena blanca ó talco y, después se coloca encima el marco superior y se rellena.

Se abre el molde para sacar el modelo, lo que constituye el DESMOLDEO. Para ello conviene mojar ligeramente con un pincel la línea de contorno del modelo en el plano de la junta, para facilitar el deslizamiento de las paredes del modelo que quedan verticalmente en el molde.

Con la ayuda de la varilla, hincada en el modelo, se procede a levantarlo, desprendiéndolo del molde.

IMPORTANCIA DE LA SALIDA.- El desmoldeo es una operación delicada, que se facilita mucho gracias a la (salida) que pueda darse a los modelos.

En efecto, cuando las paredes del modelo no son exactamente paralelas, en el sentido del moldeo, el contacto con la arena cesa desde el comienzo del desmoldeo, lo que favorece la conservación de la impresión del modelo en la arena.

Si el modelo no presenta (salida), sus paredes

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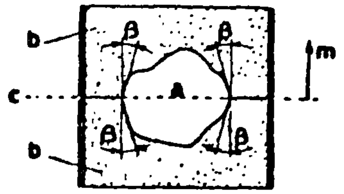


FIG. 1. — Significado de la salida: b son las dos partes del molde, m, la dirección de desmodelado. Para poder extraer el modelo a, éste debe presentar en el plano de separación c una sección máxima y tener inclinadas de un ángulo β las paredes del contorno, inclinación que se llama salida.

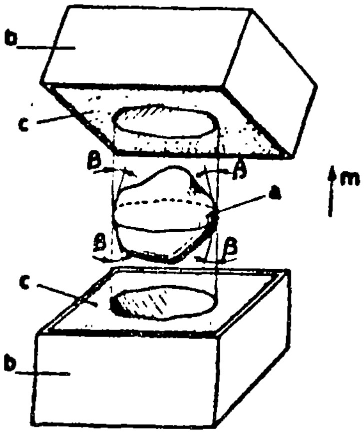


FIG. 2. — El molde está abierto y el modelo ha sido extraído.

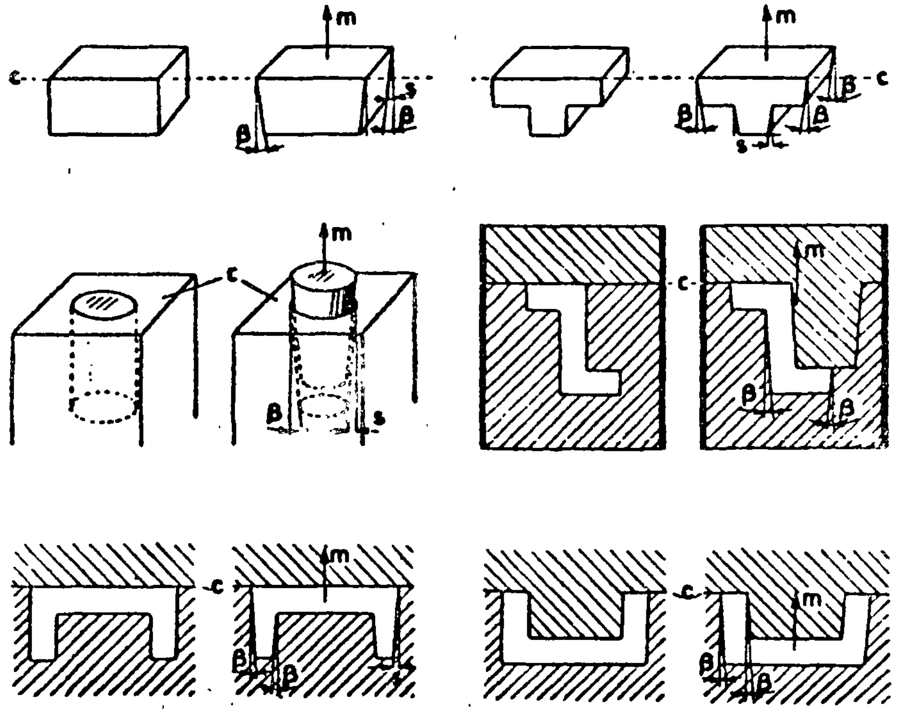


FIG. 3. — Manera en que el modelista debe modificar las formas geométricas para dar la salida y hacer posible la extracción de los modelos.

rozan con la arena, en toda su longitud, al desmoldear.

Por último, si el modelo tiene (contrasalida), el modelo no puede extraerse del molde sin arrancar arena, lo que obliga al moldeador a reparaciones que son siempre largas y delicadas.

Observación.- Ya veremos que si obligadamente ha de darse contrasalida, debido a la forma de la pieza, existen procedimiento de moldeo que soslayan esa dificultad.

Todas las partes del moldeo situadas al mismo lado de la junta deben tener la salida en el mismo sentido. Por lo tanto, si en un mismo modelo existen partes - con salida en sentido opuesto, la junta deberá pasar necesariamente por la línea de separación de los sentidos de salida.

En el ejemplo anterior, si la salida estuviera dispuesta, el plano de la junta deberá ocupar una posición distinta de la adoptada en el primer caso, lo que complicaría inutilmente el moldeo, obligando a la ejecución de una falsa mitad.

En la caja superior se procede a la ejecución - de un AGUJERO DE COLADA O BEBEDERO, y de un RESPIRADERO.- En la inferior se talla un canal de colada y un depósito - de colada que completan la preparación del molde, quedando a punto para recibir el metal en fusión.

Para evitar que el molde se abra por la presión ejercida por el metal líquido, se toma la precaución de cargar la parte superior y se solidarizan ambas partes mediantes pernos, pasadores y chavetas que las atraviesan.

Al conjunto de estas operaciones se le denomina remoldeo.

Después de colado y enfriado el metal, se rompe

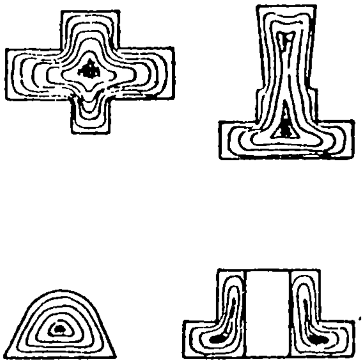


Fig. 434. — Líneas isotérmicas en piezas de sección diversa. Las zonas centrales oscuras tienden al rechupe si la composición del metal o la alimentación no son adecuadas.

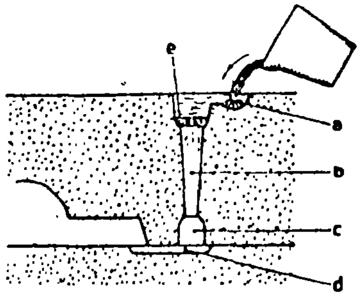


Fig. 435. — Bebedero con filtro: a, cubeta; b, cuello; c, colector; d, entrada a la pieza; e, filtro.

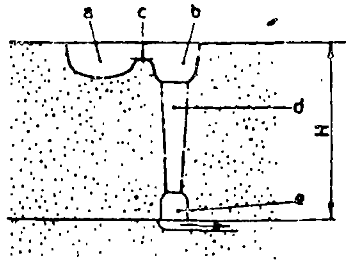


Fig. 436. — Bebedero simple: a, cubeta; b, pozuelo; c, altar; d, cuello; e, colector; H es la presión del líquido o carga metalostática.

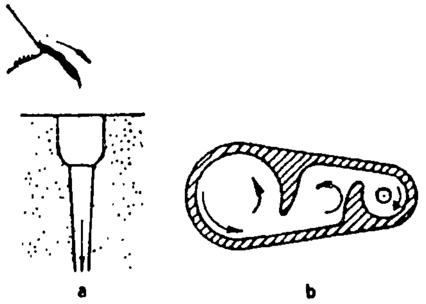


Fig. 437. — En a, bebedero simple de taza; en b, cubeta de remolino; la escoria, por la fuerza centrífuga, se reúne al centro de cada pozuelo porque es más ligera y no es arrastrada al cuello del bebedero.

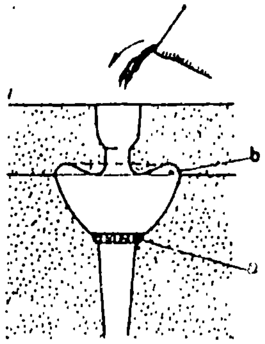


Fig. 438. — Bebedero de anillo a la italiana. El bebedero está provisto de un filtro y las impurezas, las escorias, etc., se reúnen en la cavidad anular b, y no son arrastradas al cuello.

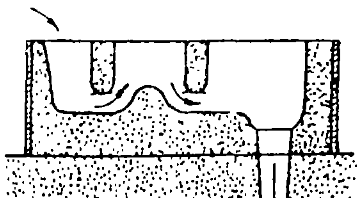


Fig. 439. — Bebedero de sifón, para la separación de las escorias.

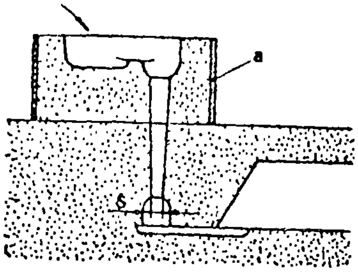


FIG. 440. — Bebedero de cubeta hecho en una caja de realce a superpuesta al molde.

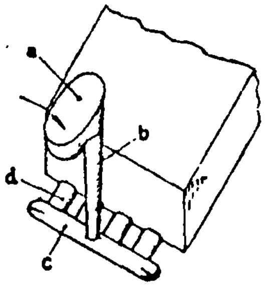


FIG. 441. — Cómo se presenta el bebedero después del enfriamiento y desmoldeo de la pieza: a, cubeta; b, cuello; c, colector; d, canales de entradas a la pieza.

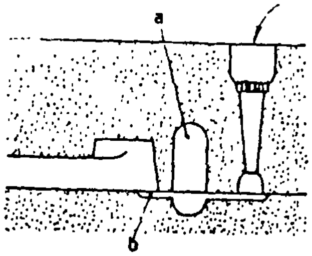


FIG. 442. — Bebedero con filtro y alimentador a: es un sistema muy usado para el acero, fundición maleable y aleaciones ligeras.

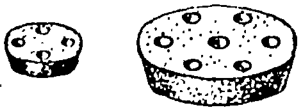


FIG. 443. — Filtros para bebederos de arena aglomerada: cambiando el diámetro y el número de los agujeros, se cambia la velocidad de colada.

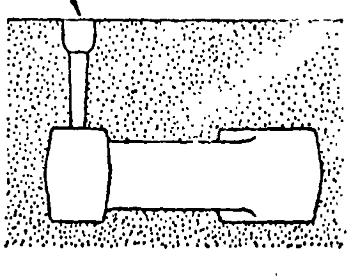


FIG. 444. — Colada directa por bebedero sencillo y único.

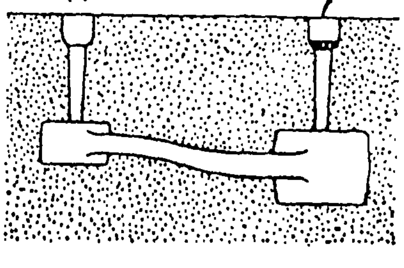


FIG. 445. — Colada directa por bebedero sencillo de filtro y cargador.

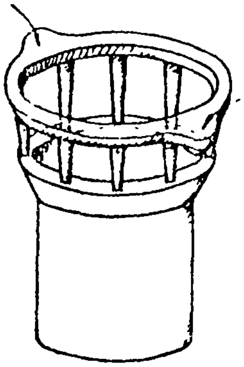


Fig. 446 — Bebedero de lluvia en dos alas. Es un sistema muy usado para cilindros huecos más bien cortos.

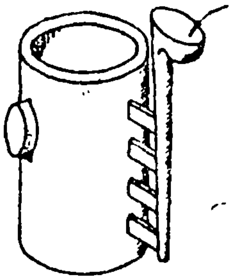


Fig. 447. — Bebedero de peine. Los canales de entrada a la pieza pueden ser horizontales, como en la figura, o inclinados hacia el interior o exterior de la pieza.

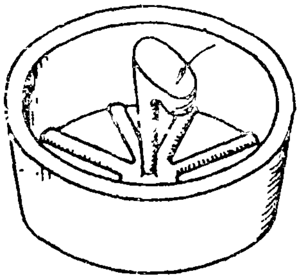


Fig. 448. — Bebedero en estrella, a propósito para anillos de gran diámetro; alguna vez los rayos se hacen en forma de S.

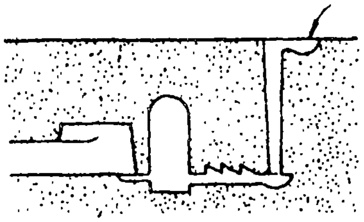


Fig. 449. — Bebedero con cubeta, separador dentado y alimentador. Las escorias (más ligeras) son detenidas por los dientes adecuadamente orientados.

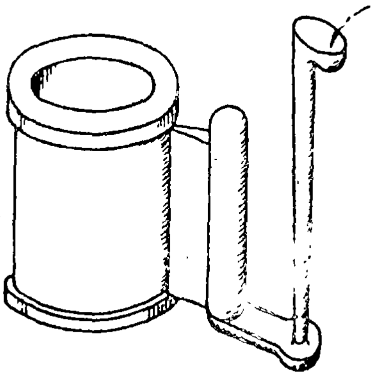


Fig. 450. — Bebedero de cuña vertical con alimentador ciego.

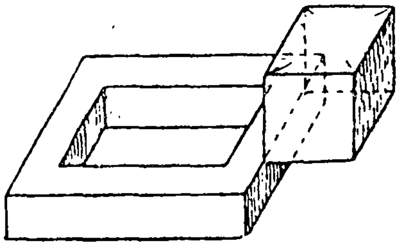


Fig. 451. — Bebedero de O'Connor, de cuña o grieta horizontal. La grieta debe ser larga, pero con un espesor de aprox. 1.5 mm.

el molde para extraer la pieza.

La pieza obtenida reproduce la forma del modelo, con los aditamentos del embudo de colada, canal y respiradero. El DESBARBADO elimina estos elementos, accesorios y regulariza ciertos efectos del moldeo, sobretodo los que aparecen en la junta; así queda la pieza con su forma definitiva.

MOLDEO ORDINARIO CON FALSA MITAD.

Este procedimiento de moldeo se impone cuando el modelo no presenta ninguna superficie exterior plana que -- pueda utilizarse como plano de junta de las cajas, a partir del cual las demás partes del modelo tienen (salida).

Entonces ejecuta una impresión falseada, llamada también FALSA MITAD ó CAJA FALSA. Se rellena un marco, y - realizando una excavación lígera se podrá colocar la pieza-modelo en posición correcta para rellenar la caja inferior que se encuentra ahora colocada en la parte superior. Al invertir el molde se podrá hacer el relleno ó apisonado definitivo de la caja superior. En el molde ya terminado, a punto para la colada los durmientes están dispuestos sobre el molde para que no se abra.

Se ha simplificado este problema del moldeo, utilizando (modelos abiertos), pero esta solución, aunque permite suprimir la falsa mitad, se complica con la ejecución del modelo partido. Solamente está justificado su empleo - cuando la pieza haya de reproducirse gran número de veces.

MOLDEO CON NOYO

El moldeo con noyo es necesario para ejecución de piezas con huecos.

Si el modelo fuera la reproducción fiel de la - pieza, la parte interior hueca no se podría desmoldear. Se arrancaría la arena que queda en su interior. Para evitar-piezas con huecos.

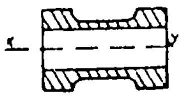


Fig. 99.

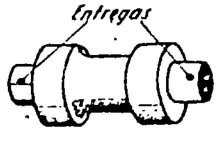


Fig. 100.
El modelo de la pieza hueca provista de sus entregas.

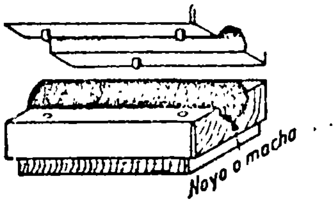


Fig. 101. — Caja de noyo.

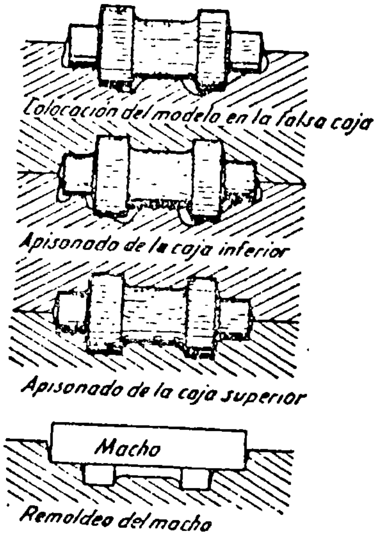


Fig. 102. — Diferentes fases de la confección del molde.

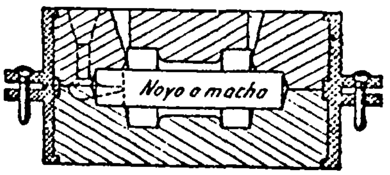


Fig. 103.
El molde dispuesto para la colada.

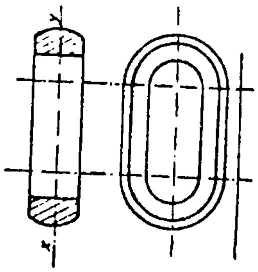


Fig. 104.

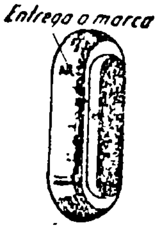


Fig. 105.
El modelo y su entrega.

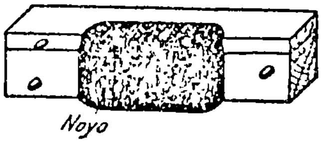


Fig. 106. — La caja del noyo.

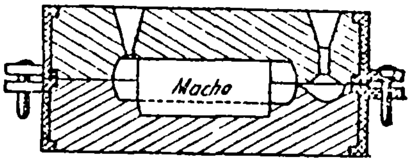


Fig. 108.
El molde a punto para la colada.

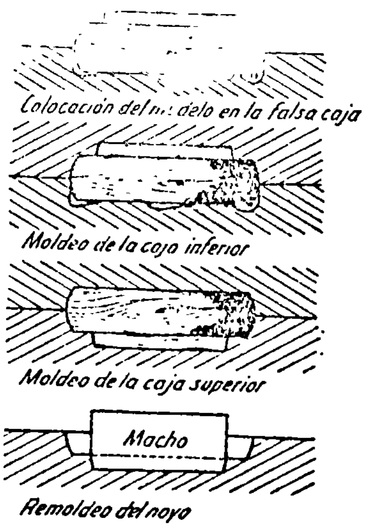


Fig. 107. — Diferentes fases de la confección del molde.

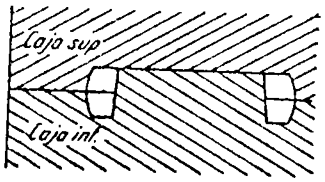


Fig. 109.

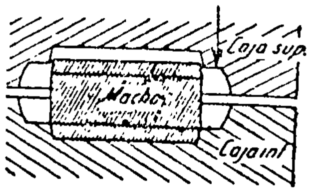
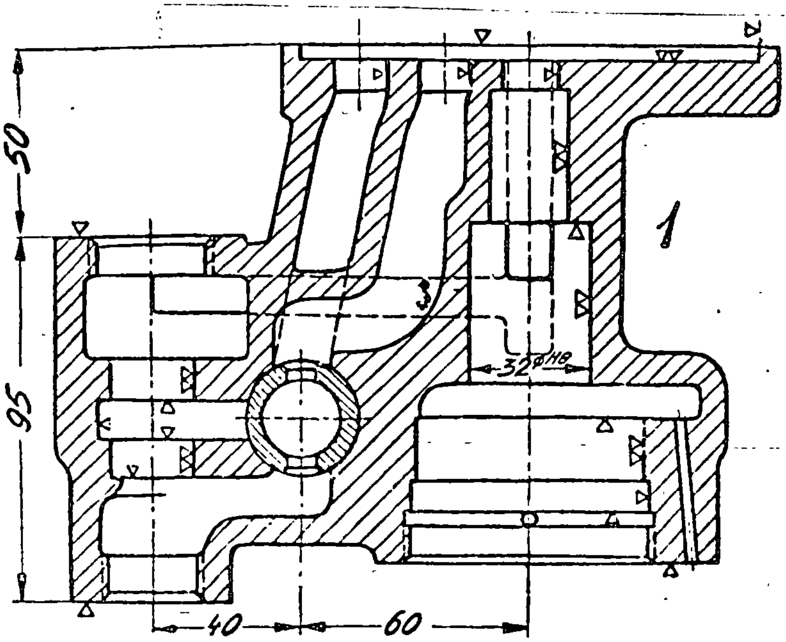


Fig. 110.
El remoldeo de la parte superior es una operación delicada.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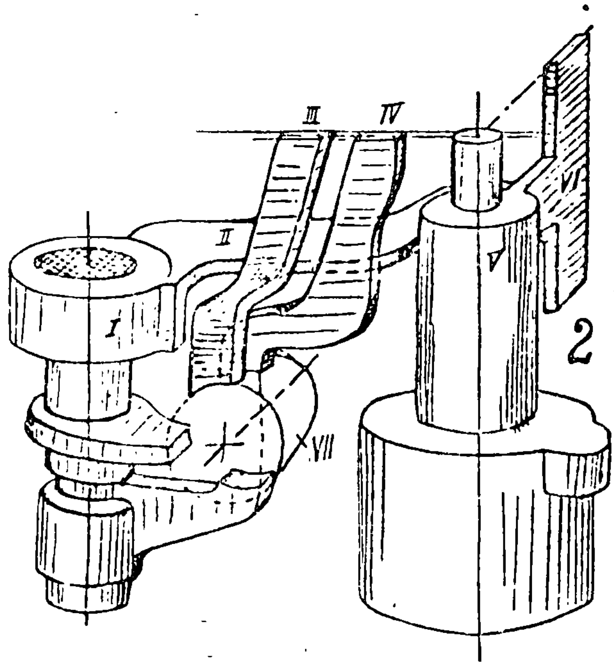
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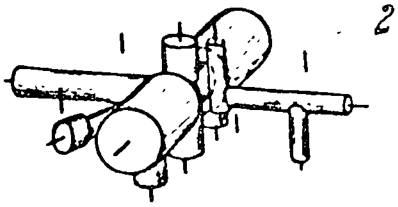
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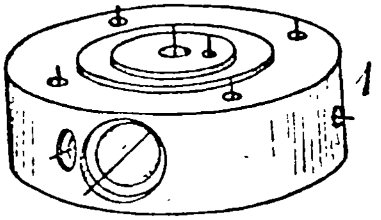
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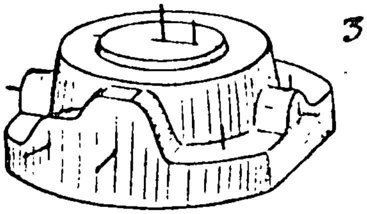
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lo, se recurre al artificio del NOYO o MACHO.

Para que esta parte de arena siga ocupando el lugar correspondiente del molde, el noyo debe quedar aprisionado en la arena del moldeo. Para ello se reservan alojamientos, denominados ENTREGAS, que se obtienen moldeando las prolongaciones correspondiente establecidas en el modelo, que -- llevan por su destino, el mismo nombre de ENTREGAS.

El noyo ó macho, a su vez, se confecciona mediante moldes especiales, llamados CAJAS DE NOYOS, que realiza el modelista.

Las diferentes fases de la confección del molde -- son: Colocación del modelo en la falsa caja; Apisonado de la caja inferior; Apisonado de la caja superior; Remoldeo del - macho, quedando listo para la colada.

Ha de advertirse que con un modelo abierto se haría innecearia, como en el caso anterior, la confección de la parte falsa.

La forma de la pieza exige que el noyo se coloque en forma vertical. La pequeña altura de éste y su sección relativamente grande le dan suficiente estabilidad en el molde con una sola entrega.

Como se vé, la influencia del modelista es predominante, pues el procedimiento de moldeo está intimamente relacionado con la disposiciones que hayn prevalecido al establecer el modelo.

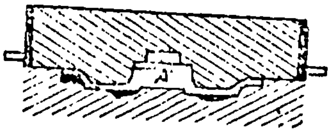
MOLDEO CON CHAPA

Cuando la pieza lleva partes entrantes, el modelo ha de tener varias juntas. Se le fracciona en tantas partes como sean necesarios para permitir el desmoldeo.

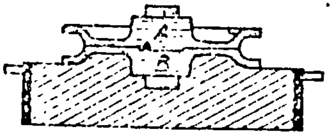
El modelo, a su vez, debe de componerse de elementos desmontables.

La solución se obtiene mediante una buena combinación de las diversas posibilidades de apertura del molde y -

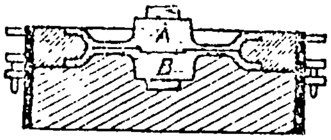
Colocar el medio modelo en la caja intermedia



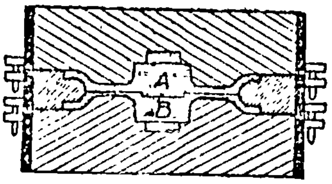
Apisonar la caja superior



Invertir el molde y colocar en su sitio la otra mitad del modelo

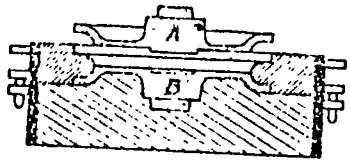


Moldear la caja intermedia

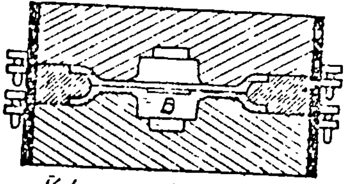


Moldear la caja inferior

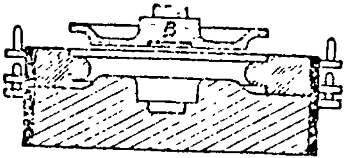
Fig. 113.
Diferentes fases del moldeo.



Levantar la caja inferior y extraer medio modelo



Volver a su sitio la caja inferior



Invertir el molde, levantar la caja superior y el otro medio modelo.

Fig. 114. — Diferentes fases del desmoldeo y remoldeo.

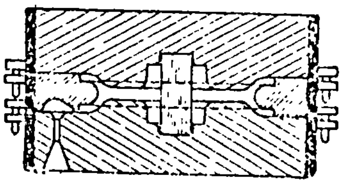


Fig. 115. — El molde terminado y a punto para la colada.

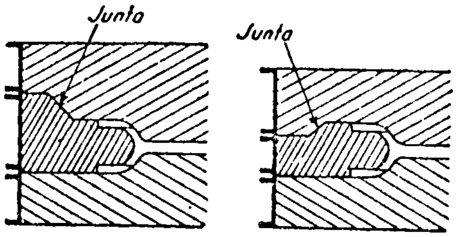


Fig. 116. — La forma de la junta varía según la altura de la caja intermedia.

desmontaje del modelo.

Pondremos de manifiesto este procedimiento con el ejemplo clásico de la polea de garganta.

Para este caso de ha establecido un modelo constituido por dos partes desmontables y una caja de noyo.

Las diferentes operaciones de moldeo son: Colocar elmedio modelo en la caja intermédia; Apisonar la caja superior; Invertir el molde y colocar en su sitio la otra mitad del modelo; Moldear la caja intermedia y moldear la caja inferior.

Para el desmoldeo y remoldeo: Levantar la caja inferior y extraer medio modelo; volver a su sitio la caja inferior e invertir el molde, levantar la caja superior y el otro medio modelo. Y por último el molde terminado y a punto para la colada.

Observación.- Para la comodidad de la representación, el marco que constituye la chapa se ha elegido de una altura igual al espesor de la misma. Pero esto no es una regla establecida. Si el marco no tiene la altura deseada, modificando la forma de la junta se puede mitigar la diferencia con facilidad.

El procedimiento demoldeo depende de la forma y disposición de los elementos del modelo.

Por ejemplo, una pieza sencilla, que aparentemente, se prestaría al modelo ordinario, la presencia de dos agujeros obliga a disponer apoyos de macho.

La existencia de estos últimos modifica las posibilidades de modelo. Se observará que los apoyos son desmontables. En efecto, esta disposición se impone ante la necesidad de disponer una chapa. El modelo, por lo tanto, habrá de fraccionarse. La solución de los apoyos desmontables es la más sencilla. Atendiendo al aspecto de la construcción del modelo, este procedimiento es preferible al de abrirlo por un plano medio mn, ya que la poca superficie de las jun

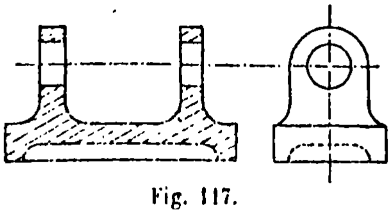


Fig. 117.

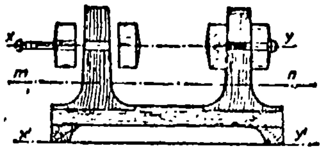


Fig. 118. — El modelo provisto de apoyos desmontables.

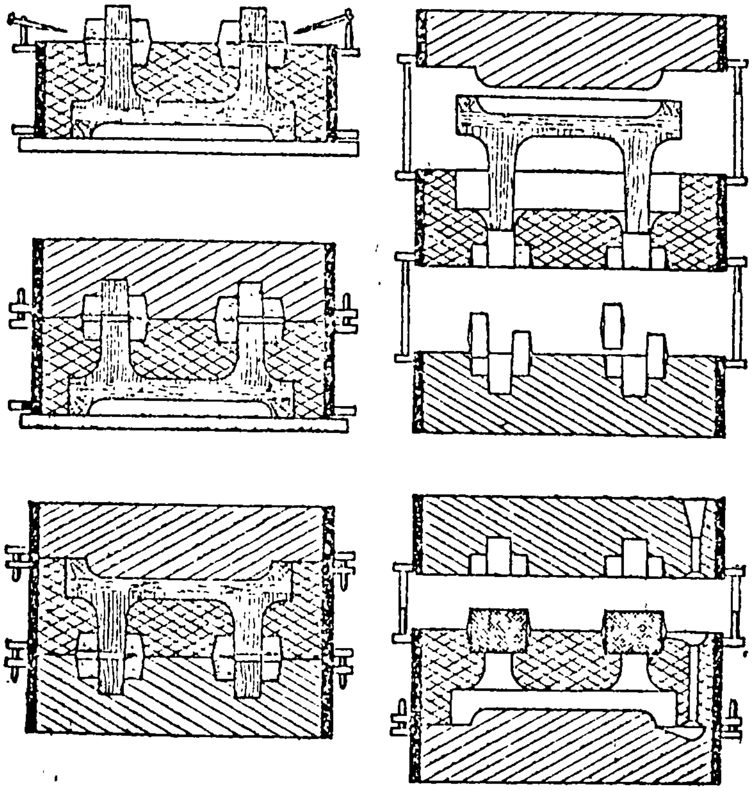


Fig. 119. — Diferentes fases de la confección del molde.

tas no daría al modelo la rigidez conveniente. Existen varias fases para la realización del molde.

Por este ejemplo se aprecia como intervienen las necesidades del moldeo en la determinación de las disposiciones que deban adoptarse para la ejecución del modelo.

Por lo que se refiere al moldeo con chapa, se observará: que el modelo ha de fraccionarse en varios elementos y que las juntas de moldeo se debendisponer en la ---- SECCION MAS FUERTE del modelo, y en cambio las juntas del - modelo han de hacerse en su SECCION MAS DEBIL,

MOLDEO CON TERRAJAS APLANTILLADAS

El moldeo de la arena recortando el relleno con plantillas de aterrajar, permite suprimir el empleo del modelo.

Este sistema es conveniente para la ejecución de un número reducido de piezas de revolución. También puede aplicarse a formas de seccion constante

En vez de construir un modelo, nos limitamos a confeccionar gálibos ó PLANTILLAS DE ATERRAJAR, las cuales han de reproducir la forma exacta del perfil de la pieza que ha de fundirse.

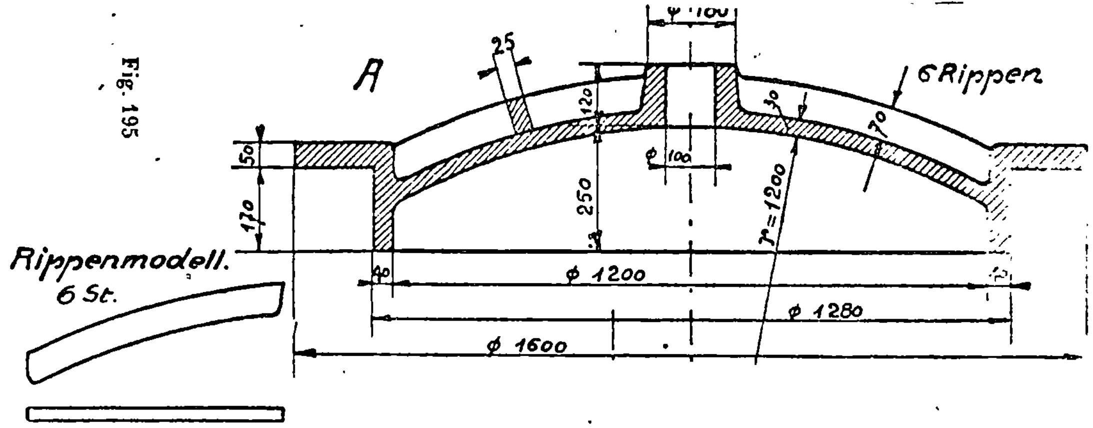
Estas plantillas cortantes, al girar alrededor de un eje tallan en la arena las forma convenientes.

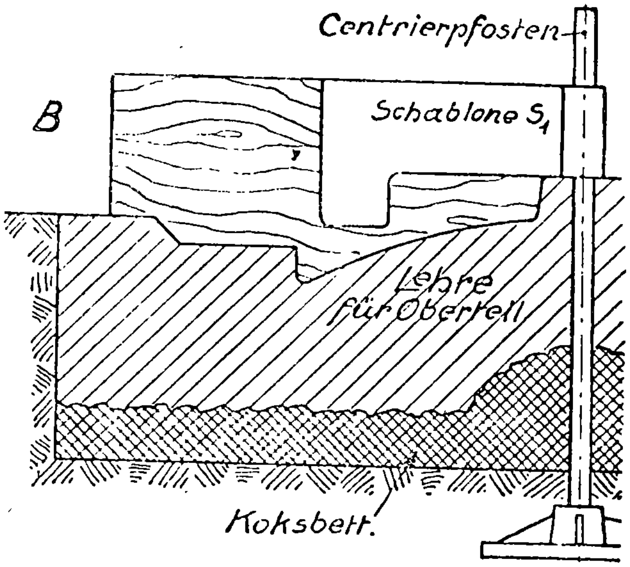
El órden de las operaciones es el siguiente:

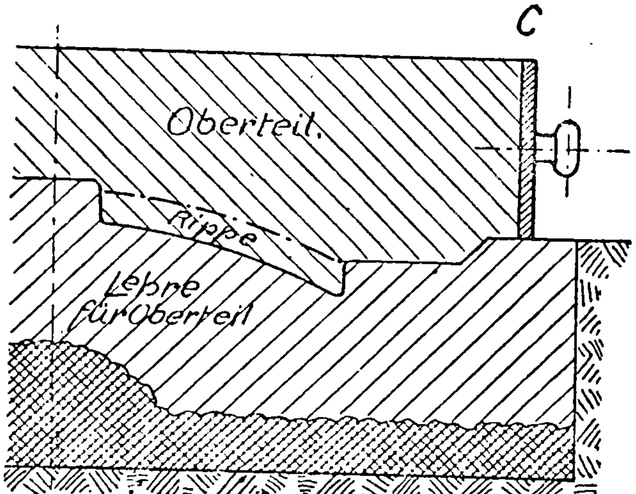
Sirviéndose de la plantilla principal, se labra en un marco, relleno de arena, una impronta que es la REPRODUCCION EXACTA de la cara superior de la pieza y de la junta de moldeo.

Esta impronta ó impresión se moldea en seguira en un bastidor que constituirá la parte superior del molde.

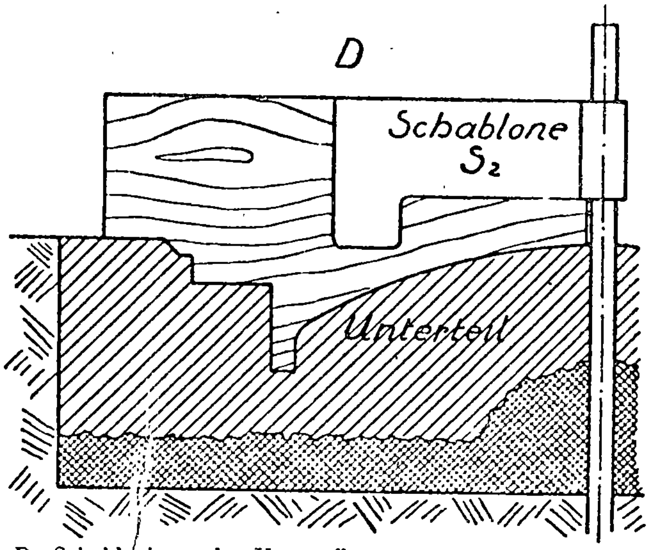
Fig. 195



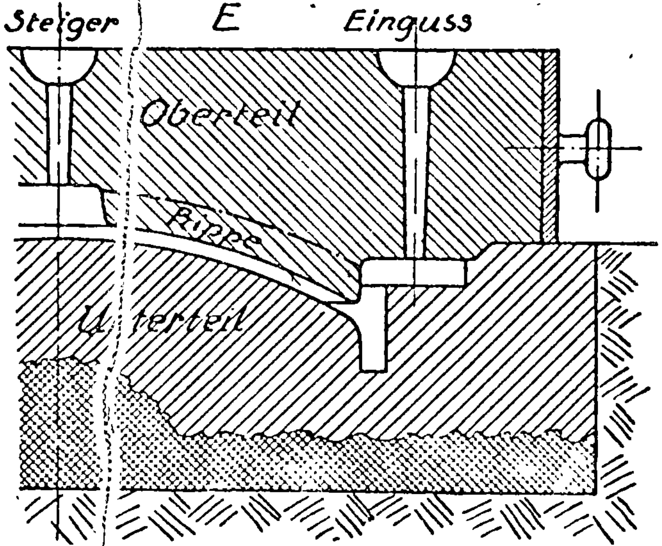




C: Aufsetzen des Formkastens, Einsetzen der Rippenmodelle in die Lehre und Aufstampfen des Oberteiles. Nach dieser Arbeit wird der Oberteil abgehoben und die Rippenmodelle werden aus nselben herausgezogen. Durch Streusand wird das Verbinden hweißen) des Oberteils mit der Lehre verhindert.



D: Schablonieren des Unterteiles.
Die Streichkante der Schablone S_2 entspricht der innern Erzeugenden des Rotationskörpers.



E: Aufsetzen des Oberteiles und Zurüsten der Form zum Gusse.

Observación.- Este moldeo suplementario tiene por objeto asegurar la perfecta concordancia de las posiciones de las dos partes del molde, haciendo que su eje sea común. Esta concordancia no se podría obtener labrando separadamente las dos partes de la caja.

De la parte superior, levantada, se hace desaparecer, mediante la plantilla secundaria, la primera impresión substituyendola por la conveniente para el moldeo de la cara inferior de la pieza.

Con esta operación se confecciona la parte inferior de la caja.

Las dos partes retocadas y ajustadas constituyen el molde.

El papel del modelista, en este caso, se limita a la ejecución de las plantillas de aterrajar y de algunos accesorios que pueden ser necesarios para la ejecución de formas más complicadas.

MOLDEO CON MAQUINA

Las operaciones de moldeo y desmoldeo pueden efectuarse con máquinas de moldear.

Para estas máquinas se emplean modelos especiales:

Las PLACAS MODELO.

Las máquinas de moldear permiten confeccionar los moldes muy rapidamente. Comprimen la arena de manera uniforme, con lo que se elimina el riesgo de que aparezcan rebabas debidas a un apisonado defectuoso.

En cambio, no pueden emplearse más que para trabajos de gran serie que permitan amortizar los gastos de establecimiento de las placas modelo, siempre elevados.

10-e

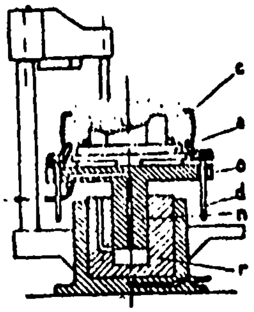


FIG. 192. — Máquina de modelar por sacudidas y compresión, como la anterior. a, placa-modelo; c, caja, o, mesa; d, espigas para el desmodelado; n, pistón de sacudidas; r, pistón de compresión. El plato está desviado lateralmente, y la máquina en la fase de sacudimiento.

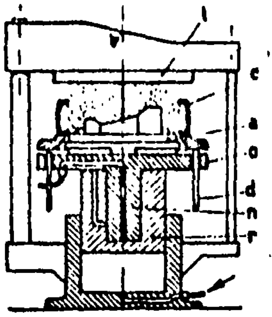


FIG. 193. — La misma máquina de la figura anterior. El plato está en el centro de la máquina y fijado por el montante de la derecha. La máquina está en la fase de compresión.

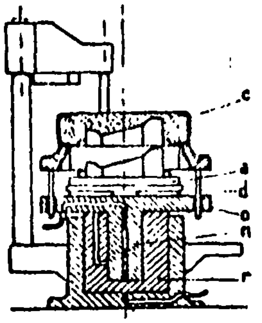


FIG. 194. — La misma máquina de la figura precedente. El plato está desviado lateralmente y la máquina en la fase de desmodelar

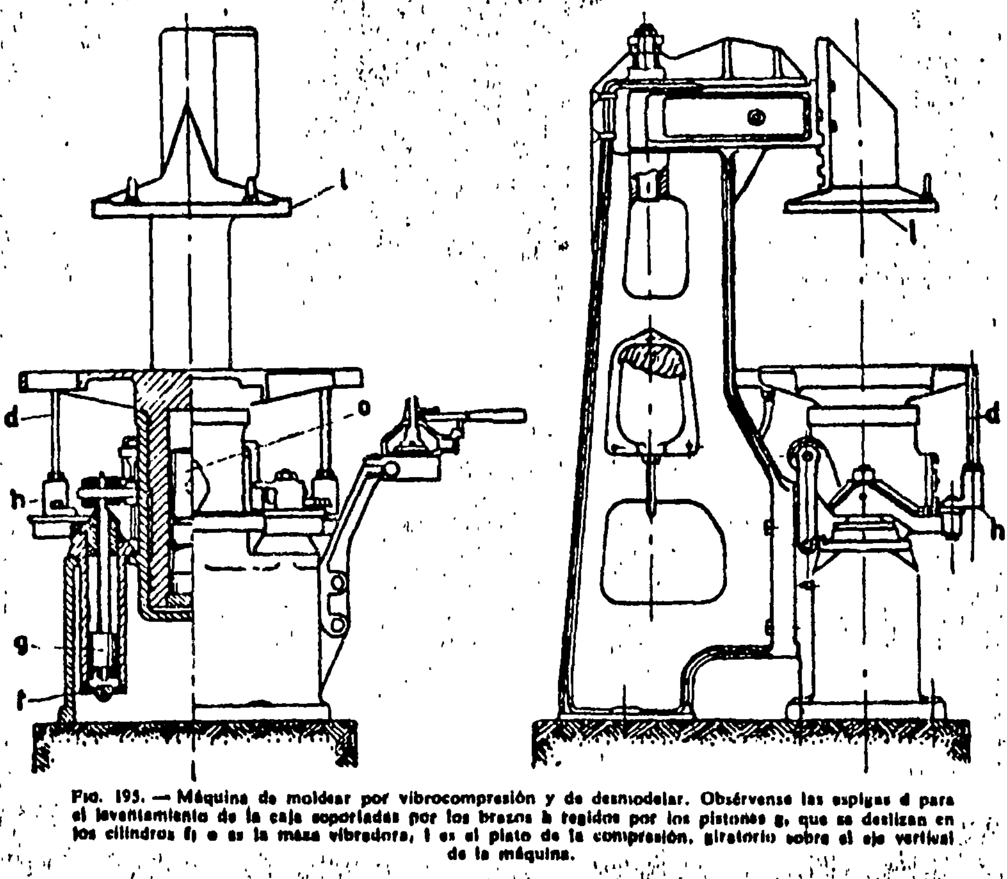


FIG. 195. — Máquina de moldear por vibrocompresión y de desmodelar. Obsérvense las espigas d para el levantamiento de la caja soportadas por los brazos h regidos por los pistones g, que se deslizan en los cilindros f; o es la masa vibradora, l es el plato de la compresión, giratorio sobre el eje vertical de la máquina.

10-F

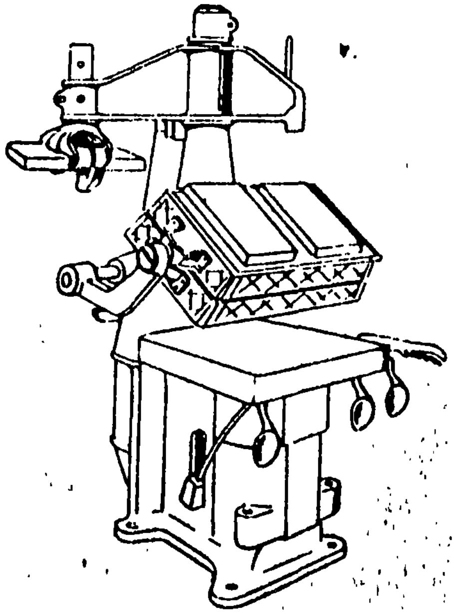


FIG. 196. — Máquina de moldear por sacudidas y compresión con brazos para sostener la placa-modelo de dos caras y las dos medias cajas. Obsérvense el plato girado alrededor de 90°, la placa-modelo, la caja en el momento de ser invertida y los mandos de rodilla para que el operario tenga libres las manos.

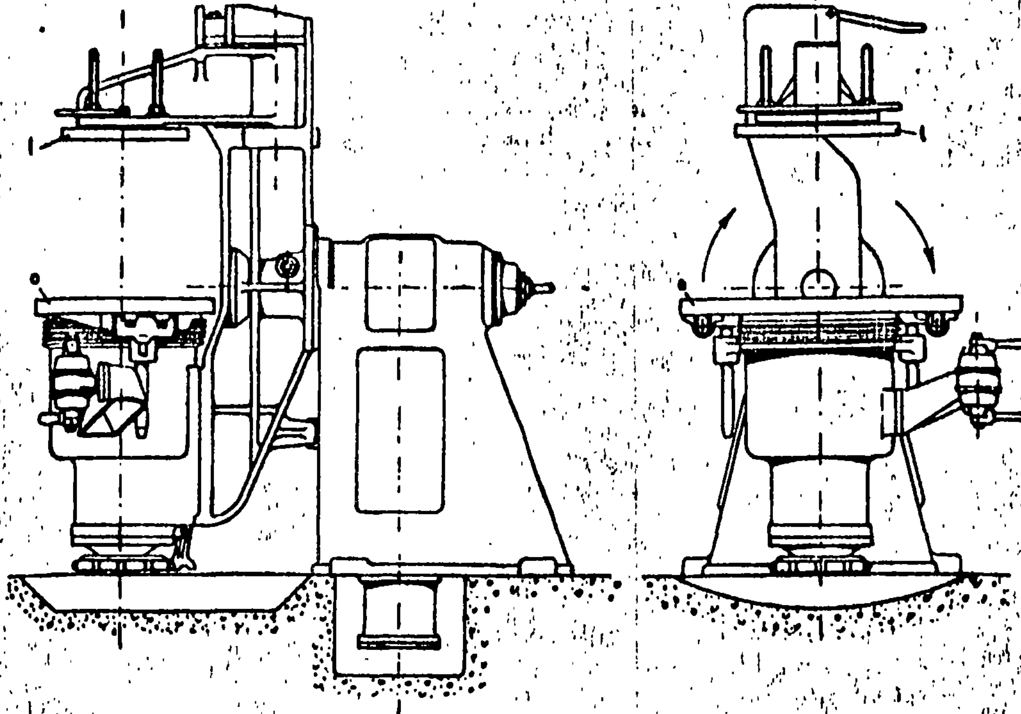


FIG. 197. — Máquina de moldear por sacudidas y compresión, invertible, de cabezal giratorio. Obsérvense el eje de rotación, el plato l y la mesa e.

16

CLASIFICACION DE LOS MODELOS SEGUN EL NUMERO DE PIEZAS QUE SE HAYAN DE FUNDIR.

En la práctica, los modelos se clasifican en cuatro categorías, según el número de piezas que hayan de reproducir.

Modelos lígeros.

Modelos para pequeña serie.

Modelos para serie

Modelos para grandes series.

MODELOS LIGEROS.- Son los que sirven para ejecutar un número reducido de piezas. Las partes macizas se construyen de pino ó abeto y los detalles de aliso ó tilo.

Los acuerdos se marcan de negro.

Las partes que tienen contrasalida pueden ser desmontadas y, en tal caso, van simplemente a tope, fijándolas con tornillos de cabeza redonda, o bien forman cuerpo con el modelo dejando al moldeador el cuidado de sacarlas EMPLEANDO PIEZAS POSTIZAS.

Los MODELOS DE ARMAZON y las plantillas de terraja entran en esta categoría.

MODELOS PARA PEQUEÑA SERIE.- Se emplean cuando hay que moldear algunas decenas de piezas.

Estos modelos, cuando son de pequeñas dimensiones, se construyen de olmo, y los detalles, de nogal.

Los modelos de mayores dimensiones se hacen de roble, encina y olmo.

Se construyen con todos los acuerdos de super-

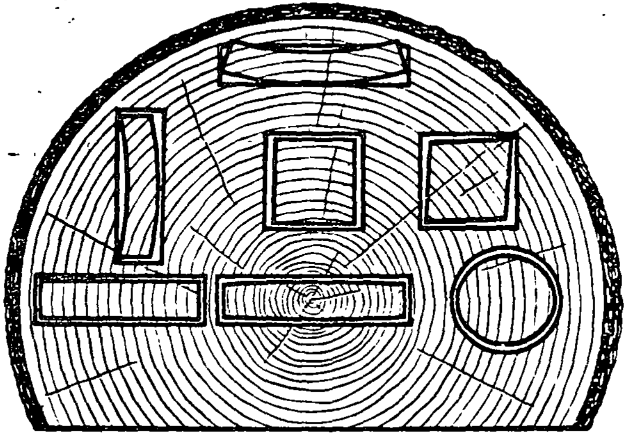
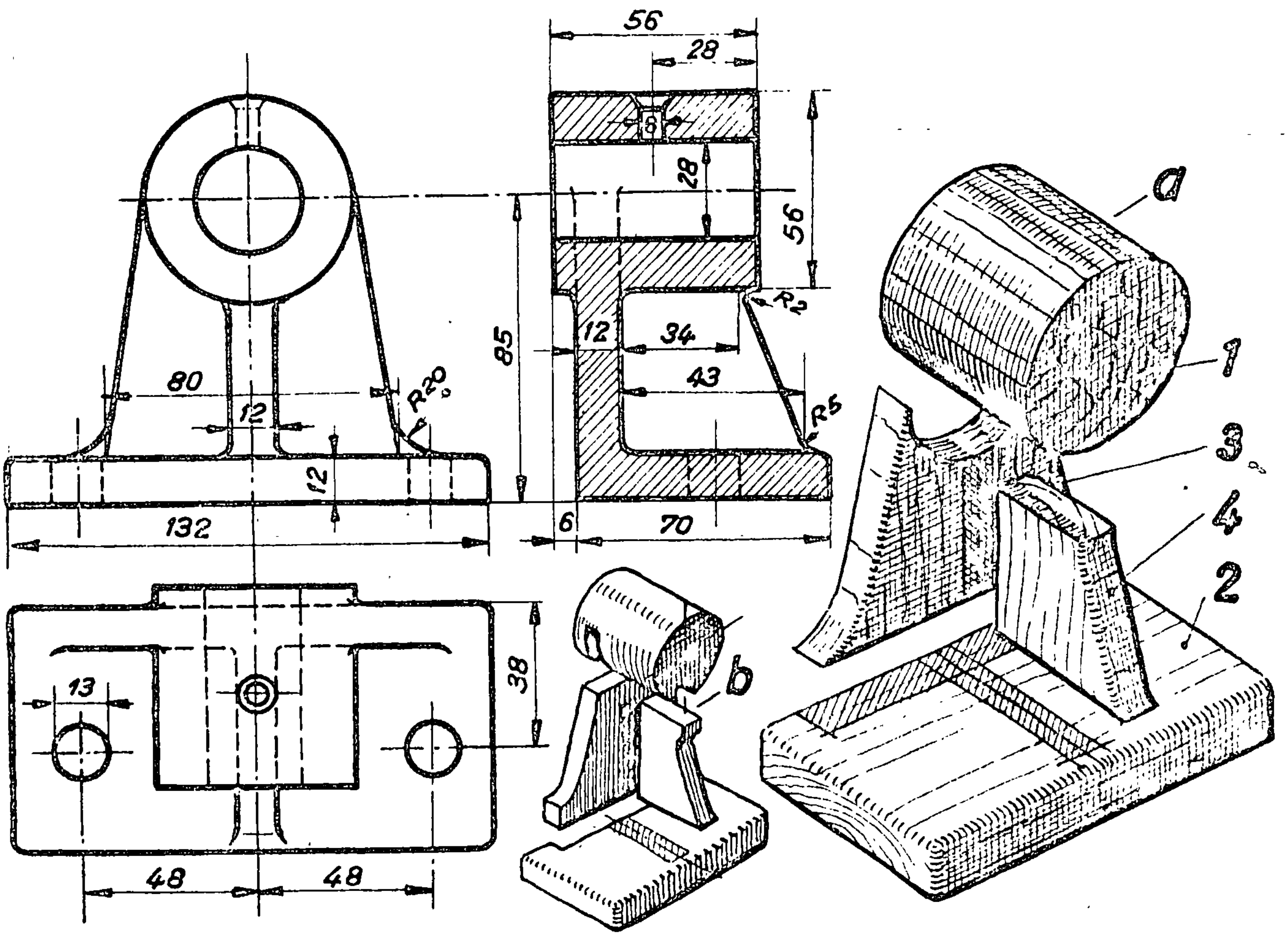
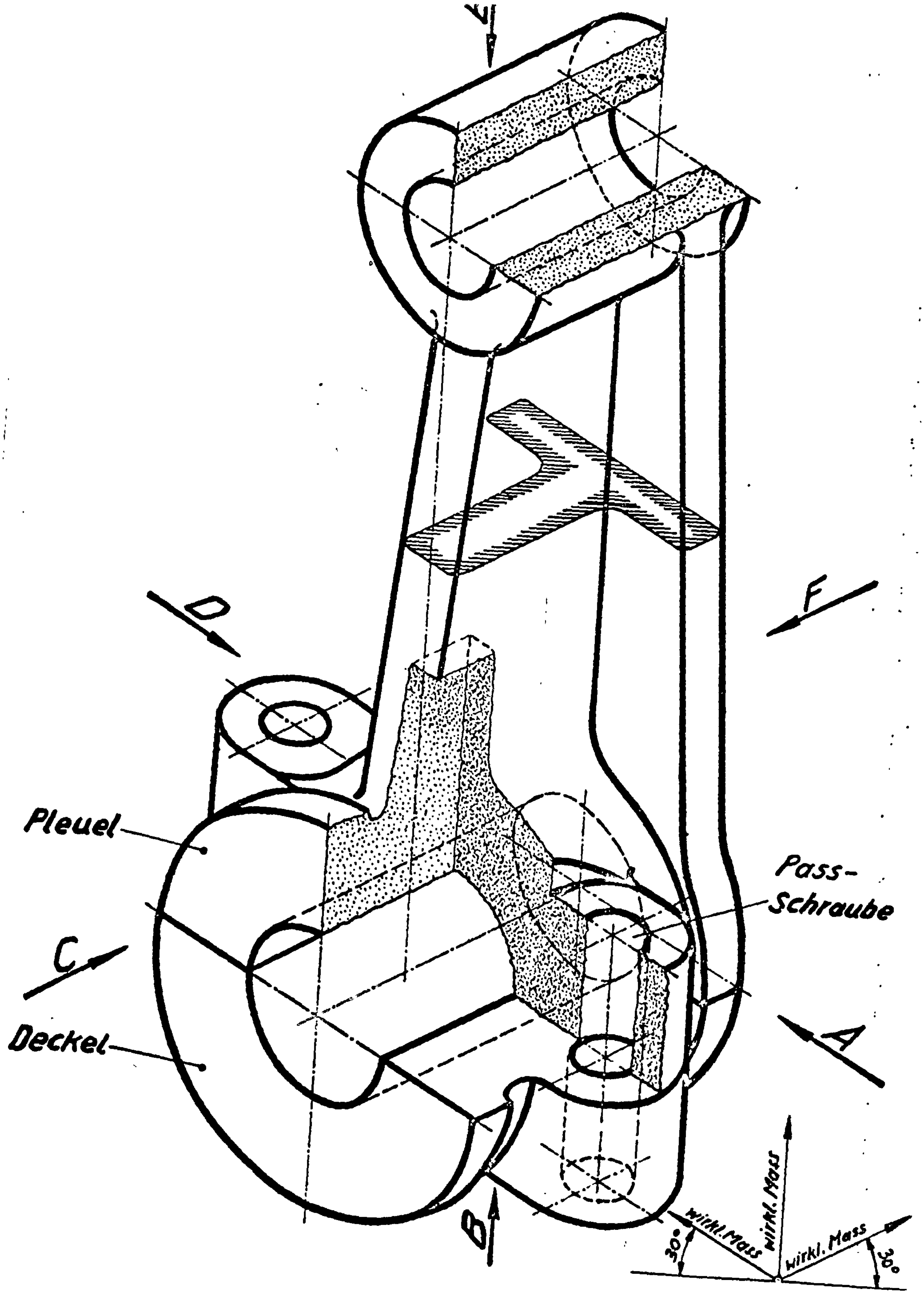
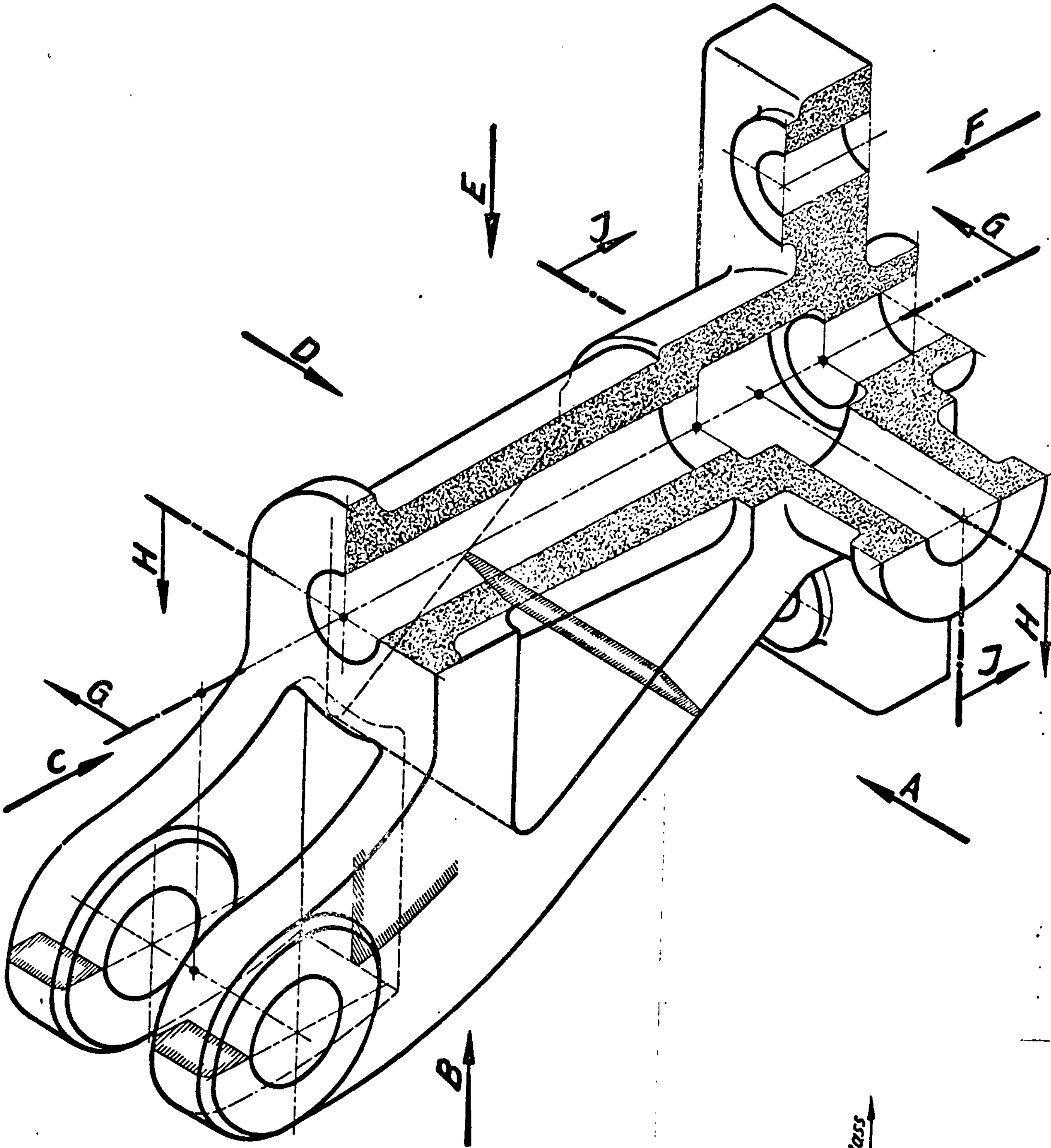
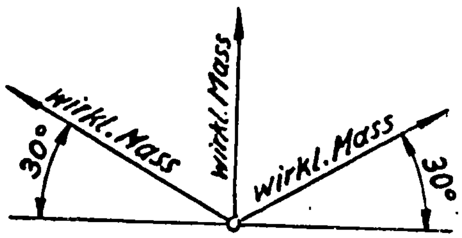


Abb. 53
Verzerrung von Holzquerschnitten infolge der Schwindung


56
28
8
28
56
R2
85
12
34
43
R5
6
70
80
R20
12
12
132
13
38
48
48
a
1
3
4
2
b


A
D
F
Pleuel
Pass-
Schraube
C
Deckel
A
B
wirkl. Mass
wirkl. Mass
wirkl. Mass
30°
30°


E
J
D
F
G
H
G
C
H
J
A
B


30°
wirkl. Mass
wirkl. Mass
wirkl. Mass
30°

ficios generalmente realizados con cuero.

Las partes desmontables se ensamblan a cola de milano. Pueden ser abiertos, si su forma exige esta disposición. Se barnizan siempre.

LOS MODELOS PARA SERIE.- Son los que se construyen para realizar gran número de piezas: varios centenares.

Deben ser muy robustos, de gran precisión y buen acabado; pero, sobretodo han de estudiarse de modo que - puedan moldearse con rapidez.

Se hacen abiertos cuando ello sea posible. Se recurre a los noyos, con preferencia a las partes desmontables.

Los acuerdos de superficies se labran en la masa.

Estos modelos van siempre barnizados.

Las maderas que se emplean en su construcción son las duras: Castaño, peral, nogal, encina, olmo....

Las ensambladuras han de realizarse con especial cuidado.

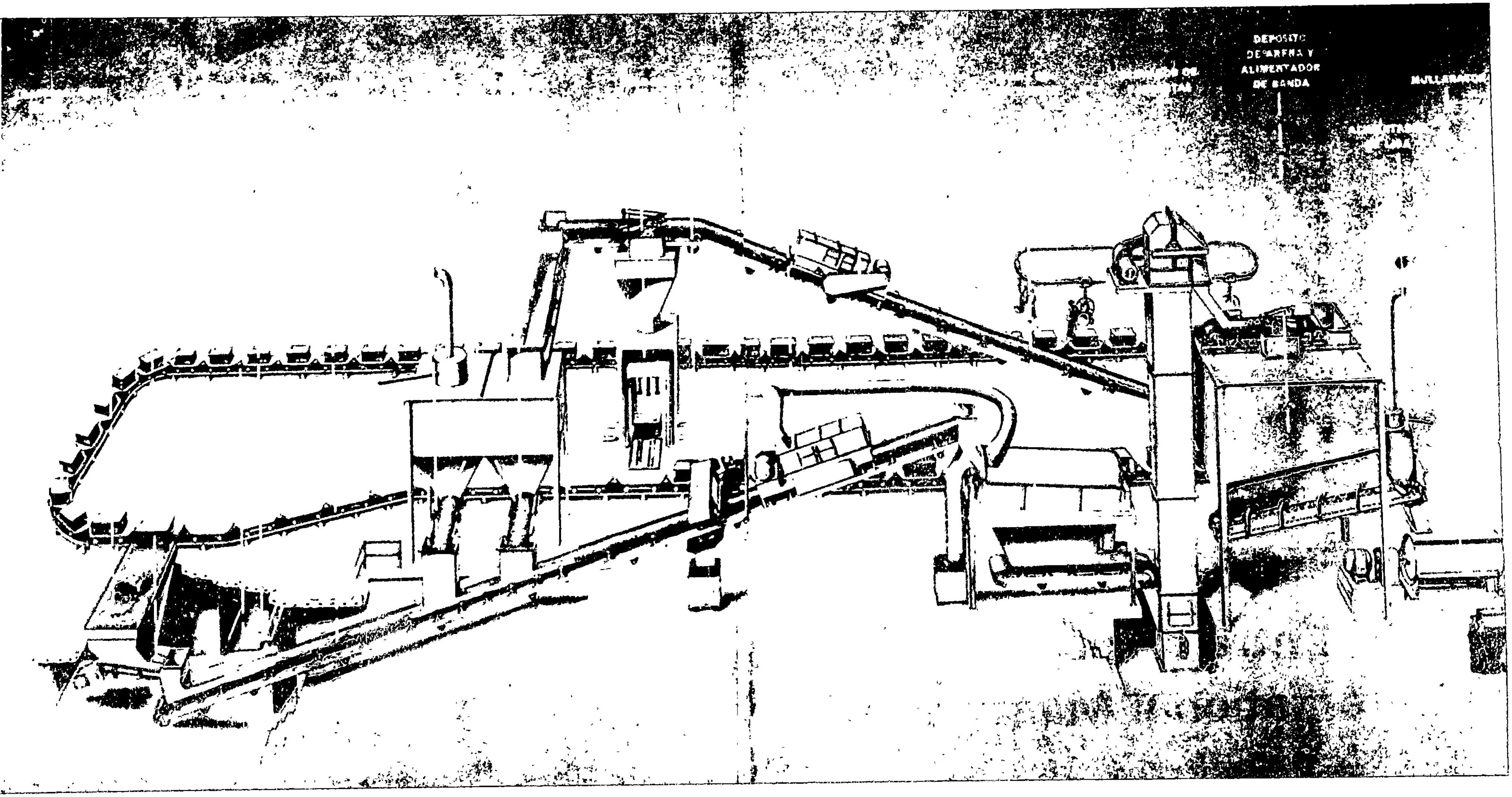
Cuando sea indispensable añadirles partes desmontables, deben estar constituidas por partes metálicas solidamente centradas.

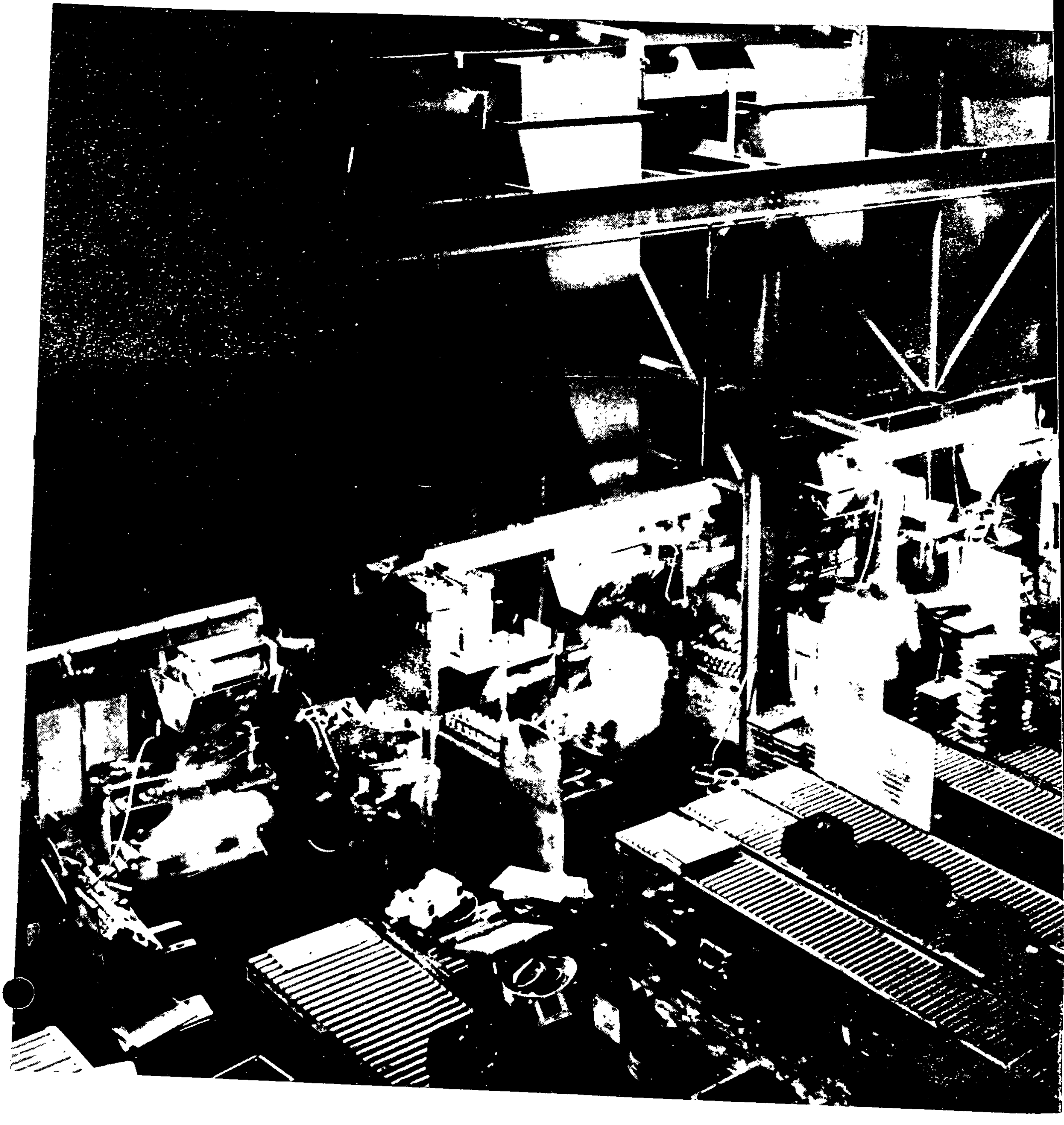
Las caras apisonadas de las cajas de noyo se protegen con placas metálicas. Las cajas de noyo se completan si su forma lo requiere, con coquillas metálicas - de secado.

LOS MODELOS PARA GRANDES SERIES.- Son los que deben permitir la ejecución de un número indefinido de piezas.

Deben de presentar la máxima resistencia al desgaste.

Generalmente son metálicos y se montan sobre placas modelo para efectuar el moldeo mecánicamente.


DEPOSITO
DE ARENA Y
ALIMENTADOR
DE BANDA
MULLERAD



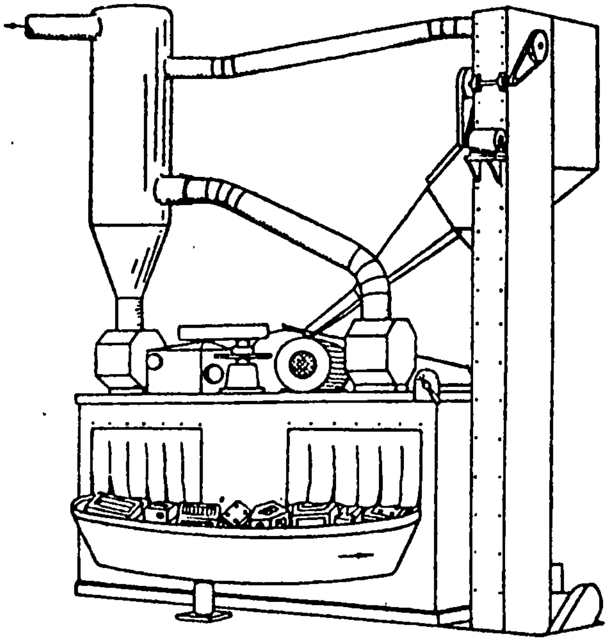


Fig. 487. — Limpiadora de chorro de arena, de mesa giratoria, con aspiración del polvo (a la izquierda) y recuperación de la arena (a la derecha).

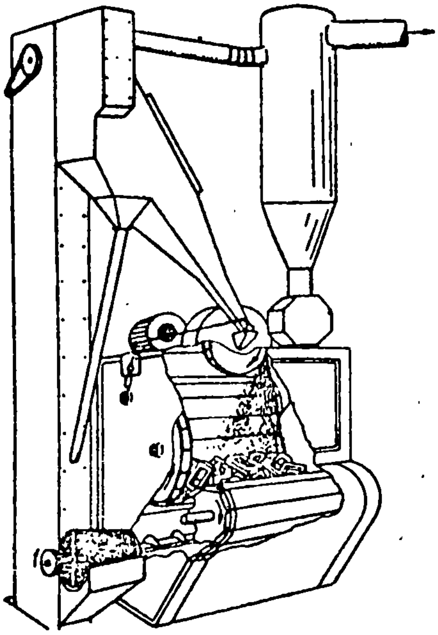


Fig. 488. — Limpiadora con transportador articulado de cadena y lanza de chorro centrífuga de granalla, con aspiración de polvo (a derecha) y recuperación de la arena (a izquierda).

TABLA AT 6 PROPIEDADES TIPICAS DE LOS MATERIALES FERROSOS FUNDIDOS [2.1,2.8,2.14,2.16,2.17]

MATERIAL N.° ESPECIFICACIÓN	RESISTENCIA MÁXIMA s_u ksi	RESISTENCIA MÁXIMA s_{uc} ksi	RESISTENCIA MÁXIMA s_{us} ksi	RESISTENCIA MÁXIMA *Tors.* ksi	RESIS. TRANSV. libras (*c*)	LIMITE DE FATIGA s'_n (*i*) ksi	FLUENCIA EN TRACCIÓN s_y ksi	MÓDULO ELASTICIDAD $E \times 10^{-6}$ psi	MÓDULO DE CIZALLADURA $G \times 10^{-6}$ psi	BHN	IZOD pie-lb	DENSIDAD lb/pulg^3	MAQUINABILIDAD (*b*)	MÍNIMO ESPESOR DE PARED RECOMENDA	
HIERRO GRIS (g) (fund. simplemente sin tratamiento)	(d)	(d)				(e)		(h)							
ASTM SAE(a)															
20 110	20(f)	83	32	26	1850	10		9,6(f)	3,9(f)	156		0,253		$t = 1/8$ pulg	
25	25(f)	97	35	32	2175	11,5		11,5(f)	4,6(f)	174		0,253		$t = 1/4$ pulg	
30 111	30(f)	109	41	40	2525	14		13(f)	5,2(f)	201	23	0,254	80	$t = 3/8$ pulg	
35(g) 120	35(f)	124	49	48,5	2850	16		14,5(f)	5,8(f)	212	25	0,257	65	$t = 3/8$ pulg	
40(g) 121	40(f)	140	52	57	3175	18,5		16(f)	6,4(f)	235	31	0,262	55	$t = 5/8$ pulg	
50(g)	50(f)	164	64	73	3600	21,5		18,8(f)	7,2(f)	262	65	0,269	50	$t = 3/4$ pulg	
60(g)	60(f)	187	60	88,5	3700	24,5		20,4(f)	7,8(f)	302	75	0,269		$t = 1$ pulg	
Ni-Resist, Inco K-6	25(f)	100(f)						12(f)		145	100			$t = 1/8$ pulg	
Meehanite (w)	35(f)						28(f)	12(f)		190				$t = 1/8$-$7/8$ pu	
HIERRO MALEABLE														ALARG. en 2 pulg %	RE ÁR
ASTM Grado															
A47-52 32 510	52	(o)	48	58		25,5	34	25	10,7	120	12	0,262	120	12,5	
A47-52 35 018	55	(o)	43	58		27	36,5	25	10,7	130	16	0,262	120	20	
HIERRO FUNDIDO NODULAR (j)															
60-45-10 (recocido) (q)	70	(s)		57		30	55	23	9,5	160	9-20(n)	0,26		18	
80-60-03 (fund. simplem.) (p)	88	(s)		73		40	65	23	9,9	230	2-8(n)	0,26		6	
100-70-03 (trat. térmico) (r)	110	(s)		88(e)		44(e)	80	23	9,9	270	2-6(n)			5	
ACERO MOLDEADO			MÁX. CONT. DE CARBONO Y TRATAMIENTO TÉRMICO												
ASTM SAE(a)															
A27-58(t)	60(f)	60(f)	0,3 % C, Recocido			25	30(f)	30	11,5	120	18(m)	0,284	55	30	50
A27-58(t) 0030(k)	65(f)	65(f)	0,3 % C, Normalizado			28	35(f)	30	11,5	130	23(m)	0,284	60	30	53
A27-58	70(f)	70(f)	0,35 % C, Normalizado			31	36(f)	30	11,5	140	19(m)	0,284	65	26	40
A27-58	70(f)	70(f)	0,25 % C, Normalizado				40(f)	30	11,5		30(m)	0,284			
A148-58 080	80(f)	80(f)	N&T			35	40(f)	30	11,5	160	22(m)	0,284	70	27	42
A148-58	80(f)	80(f)	WQT			35	50(f)(v)	30	11,5	170	30(m)(u)	0,284		28(u)	68
A148-58 090	90(f)(v)	90(f)	N&T			41	60(f)	30	11,5	190	20(m)(u)	0,284	70	24	50
A148-58 0105	105(f)	105(f)	WQT			49	85(f)	30	11,5	235	28(m)	0,284	60	18	42
A148-58	120(f)	120(f)	WQT			55	95(f)(w)	30	11,5	269	25(m)	0,284		14(f)	30
A148-58 0150	150(f)	150(f)	WQT			65	125(f)	30	11,5	310		0,284		9(f)	22
A148-58 0175	175(f)	175(f)	WQT			77	145(f)	30	11,5	390	12(m)	0,284		8	15

TABLA AT 6 PROPIEDADES TÍPICAS DE LOS MATERIALES FERROSOS FUNDIDOS [2.1, 2.6, 2.14, 2.16, 2.17]

Notas: Los *coeficientes aproximados de dilatación térmica* son en cm/cm-°C (o bien en pulg/pulg-°F): hierro gris, 10 × 10^{-6} (o bien 5,6 × 10^{-6}); hierro maleable, 11,9 × 10^{-6} (o bien 6,6 × 10^{-6}); hierro nodular, 12,1 × 10^{-6} (o bien 6,7 × 10^{-6}); acero moldeado, 11,7 × 10^{-6} (o bien 6,5 × 10^{-6}) (pero varía apreciablemente con la composición). *Coeficiente de Poisson:* hierro gris, 0,211 (min.); hierro maleable, 0,265; hierro nodular, 0,16; acero moldeado, 0,27 (a) Las especificaciones ASTM y SAE no son iguales. (b) Maquinabilidad, valores relativos, AISI B1112 = 100 (c) Diámetro, 30,48 mm; soportes, 457,2 mm (o sea 1,2 pulgada diámetro, soportes 18 pulgadas). (c) Los resultados de los ensayos indican que la resistencia a la flexión del hierro fundido en secciones *simétricas*, calculada por $s_f = M/Z$, es aproximadamente $1{,}9s_u$ a $2s_u$. Se usa $1{,}9s_u$. (e) Calculada. (f) Valores mínimos. Los valores típicos pueden estar comprendidos entre 10 y 40 % más elevados. (g) Los materiales ASTM 35 y de grado (calidad) más elevado se consideran que son de alta resistencia, y son más caros. (h) Para hierro fundido con 25 % de resistencia máxima; varía con las dimensiones de la sección y el análisis químico. (i) Flexión invertida. Para hierro gris, $0{,}4s_u < S'_n < 0{,}6s_u$. (j) El número indica las propiedades mínimas; por ejemplo, 80-60-03 indica s_u = 80 ksi (5624 kg/cm²), s_y = 60 ksi (4218 kg/cm²) (deformación permanente de 0,2 %) y alargamiento de 3 %, mínimo, en sección de 25,40 mm (1 pulgada). aproximadamente. (k) 0,3 % C, máximo. (l) N&T, símbolo de «normalizado y revenido» (en inglés, «normalized and tempered»). Las propiedades de las piezas fundidas de acero varían con los contenidos de carbono y de elementos de aleación, y con el tratamiento térmico, como en el acero forjado; mínima $s'_n \approx 0{,}4s_u$. (m) Impacto de Charpy, entalladura en ojo de cerradura, 21°C, kgm (o bien 70°F, pie-lb). (n) Impacto de Charpy, entalladura en V. (o) Se toma igual a s_u. (p) ASTM A339-55. (q) ASTM A395-56T. (r) ASTM A396-58. (s) Para el proyecto se admiten resistencias máximas de compresión y resistencias de fluencia del hierro nodular iguales a s_u y s_y, respectivamente. (t) Grados o calidades comerciales corrientes. (u) Revenido a 649° C (1200° F). (v) Típica $s_u \approx$ 6749 kg/cm² (96 ksi), s_y = 5132 kg/cm² (73 ksi) cuando WQT 1200 (o sea, templado en agua y revenido a 1200° F, equivalentes a 649° C). (w) Tipo de aplicaciones generales.

MATERIAL N.° ESPECIFICACIÓN	RESISTENCIA MÁXIMA				RESIS. TRANSV. kg (c)	LÍMITE DE FATIGA s'_n (i) kg/cm²	FLUENCIA EN TRACCIÓN s_y kg/cm²	MÓDULO ELASTICIDAD $E \times 10^{-6}$ kg/cm²	MÓDULO DE CIZALLADURA $G \times 10^{-6}$ kg/cm²	NDB	IZOD kgm	DENSIDAD kg/dm³	MAQUINABILIDAD (b)	MÍNIMO ESPESOR DE PARED RECOMENDAD	
	s_u kg/cm²	s_{uc} kg/cm²	s_{us} kg/cm²	*Tors.* kg/cm²											
HIERRO GRIS (g) (fund. simplemente sin tratamiento)	(d)	(d)				(e)		(h)							
ASTM SAE(a)															
20 110	1 406(f)	5 835	2249	1828	839	703		0,675(f)	0,274(f)	156		7,01		t = 3,17 mm	
25	1 757(f)	6 819	2460	2249	986	808		0,818(f)	0,323(f)	174		7,01		t = 6,35 mm	
30 111	2 109(f)	7 662	2882	2812	1145	984		0,914(f)	0,365(f)	201	3,18	7,04	80	t = 9,52 mm	
35(g) 120	2 460(f)	8 718	3445	3409	1292	1124		1,019(f)	0,407(f)	212	3,45	7,12	65	t = 9,52 mm	
40(g) 121	2 812(f)	9 843	3656	4007	1440	1300		1,124(f)	0,450(f)	235	4,28	7,26	55	t = 15,87 mm	
50(g)	3 515(f)	11 530	4499	5132	1632	1511		1,321(f)	0,506(f)	262	8,98	7,45	50	t = 19,05 mm	
60(g)	4 218(f)	13 147	4218	6221	1678	1722		1,434(f)	0,548(f)	302	10,36	7,45		t = 25,40 mm	
Ni-Resist, Inco K-6	1 757(f)	7 030(f)						0,843(f)		145	13,82			t = 3,17 mm	
Meehanite (w)	2 460(f)						1 968(f)	0,843(f)		190				t = 3,17-22,22	
HIERRO MALEABLE														ALARG. en 5 cm %	RED ÁR
ASTM Grado															
A47-52 32 510	3 656	(o)	3374	4077		1792	2 390	1,757	0,752	120	1,65	7,26	120	12,5	
A47-52 35 018	3 866	(o)	3023	4077		1898	2 566	1,757	0,752	130	2,21	7,26	120	20	
HIERRO FUNDIDO NODULAR (j)															
60-45-10 (recocido) (q)	4 921	(s)		4007		2109	3 866	1,617	0,668	160	1,24-2,76(n)	7,19		18	
80-60-03 (fund. simplem.) (p)	6 187	(s)		5132		2812	4 569	1,617	0,696	230	0,27-1,10(n)	7,19		6	
100-70-03 (trat. térmico) (r)	7 734	(s)		6187		3093(e)	5 624	1,617	0,696	270	0,27-0,83(n)			5	
ACERO MOLDEADO			MÁX. CONT. DE CARBONO Y TRATAMIENTO TÉRMICO												
ASTM SAE(a)															
A27-58(t)	4 218(f)	4 218(f)	0,3 % C, Recocido			1757	2 109(f)	2,109	0,808	120	2,48(m)	7,86	55	30	50
A27-58(t) 0030(k)	4 569(f)	4 569(f)	0,3 % C, Normalizado			1968	2 460(f)	2,109	0,808	130	3,18(m)	7,86	60	30	5
A27-58	4 921(f)	4 921(f)	0,35 % C, Normalizado			2179	2 531(f)	2,109	0,808	140	2,62(m)	7,86	65	26	40
A27-58	4 921(f)	4 921(f)	0,25 % C, Normalizado				2 812(f)	2,109	0,808		4,14(m)	7,86			
A148-58 080	5 624(f)	5 624(f)	N&T			2460	2 812(f)	2,109	0,808	160	3,04(m)	7,86	70	27	42
A148-58	5 624(f)	5 624(f)	WQT			2460	3 515(f)(v)	2,109	0,808	170	4,14(m)(u)	7,86		28(u)	68
A148-58 090	6 327(f)(v)	6 327(f)	N&T			2882	4 218(f)	2,109	0,808	190	2,76(m)(u)	7,86	70	24	50
A148-58 0105	7 381(f)	7 381(f)	WQT			3445	5 976(f)	2,109	0,808	235	3,87(m)	7,86		18	47
A148-58	8 437(f)	8 437(f)	WQT			3866	6 679(f)	2,109	0,808	269	3,45(m)	7,86		14(f)	3
A148-58 0150	10 546(f)	10 546(f)	WQT			4569	8 788(f)	2,109	0,808	310		7,86		9(f)	22
A148-58 0175	12 303(f)	12 303(f)	WQT			5413	10 194(f)	2,109	0,808	390	1,66(m)	7,86		8	1

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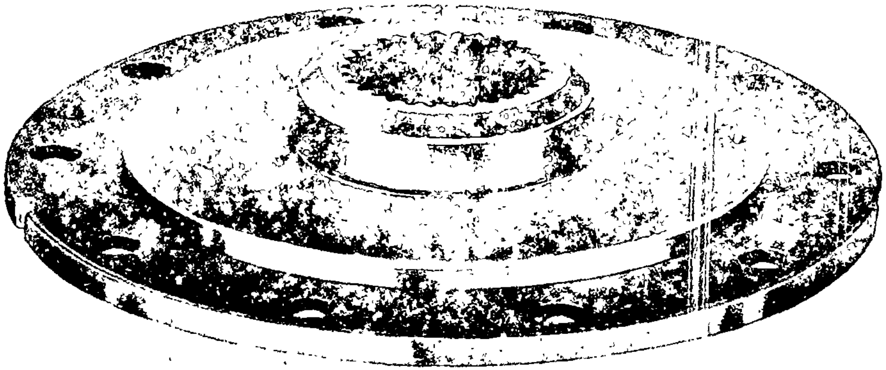
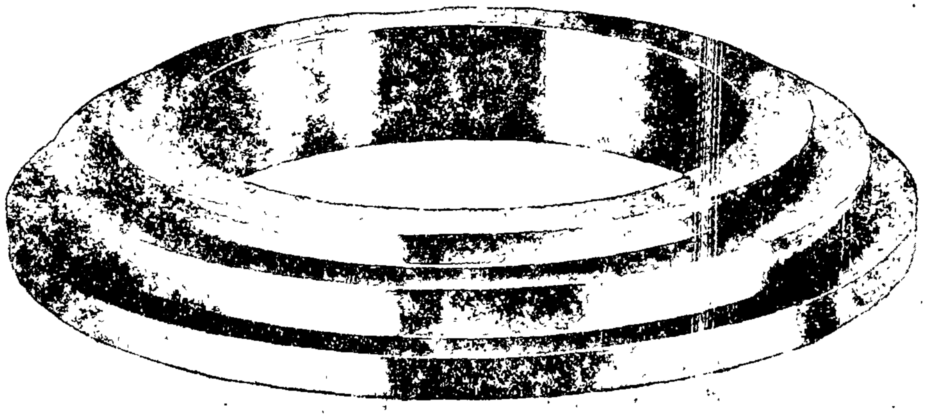
DISEÑO DE HERRAMENTAL

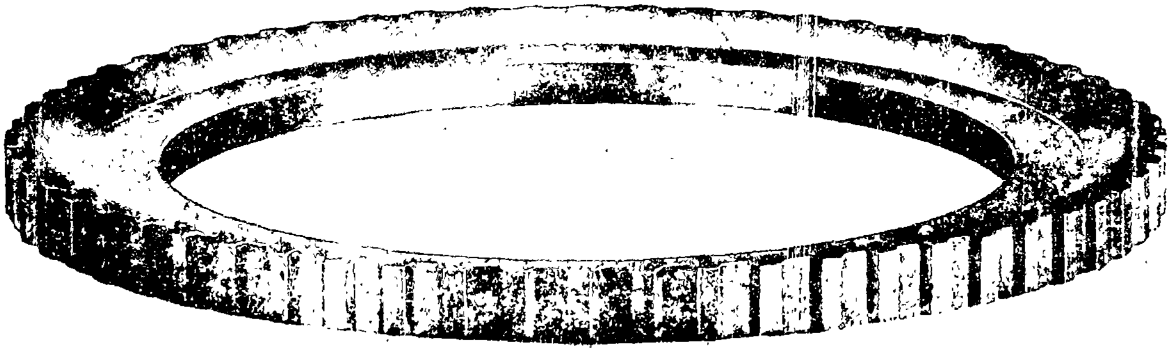
METALURGIA DE POLVOS

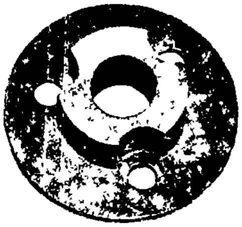
ING. ULRICH SCHARER SAUBERLI

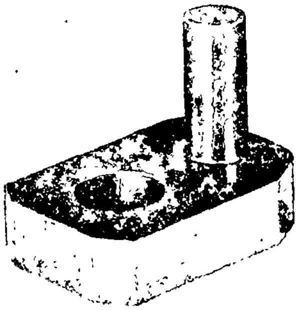
JUNIO, 1978.

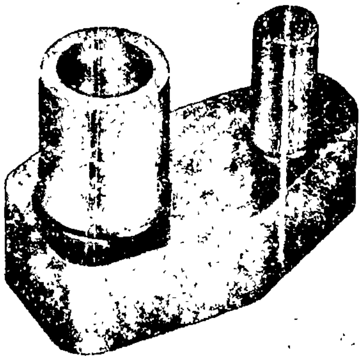




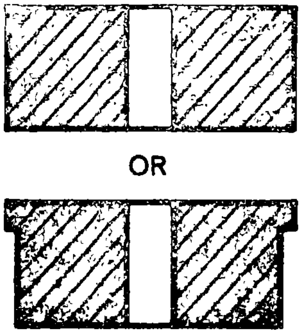




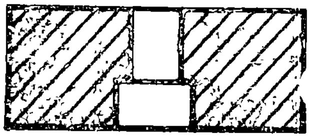




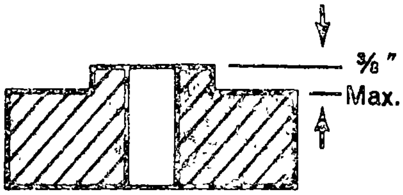
[illegible] Typical [illegible]



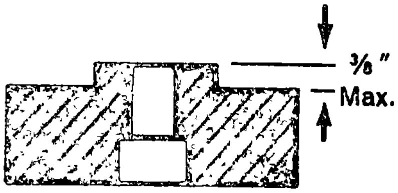
Standard press—no accessories
(Shoulder machined into die—all
ejection from bottom surface only)



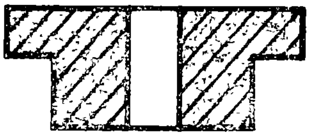
Core rod stop



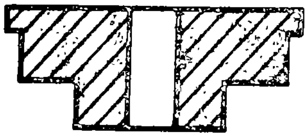
Dual upper punch



Dual upper punch
Core rod stop

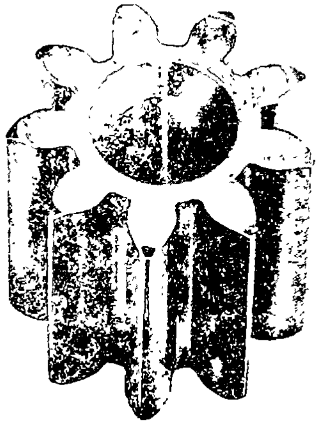


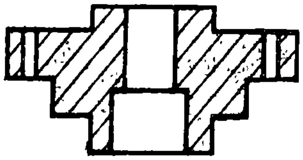
Optional platen No. 1



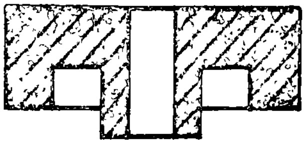
Optional platen No. 2 with stops
(Upper shoulder machined into die)

Optional platens No. 1 and No. 2





Optional platens No. 1
and No. 2
Core rod stop—Dual upper punch
eeder delay—Top punch hold-down—
Increased daylight



Optional platens No. 1, No. 2
and Selective Ejection

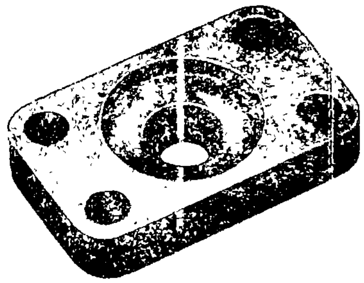
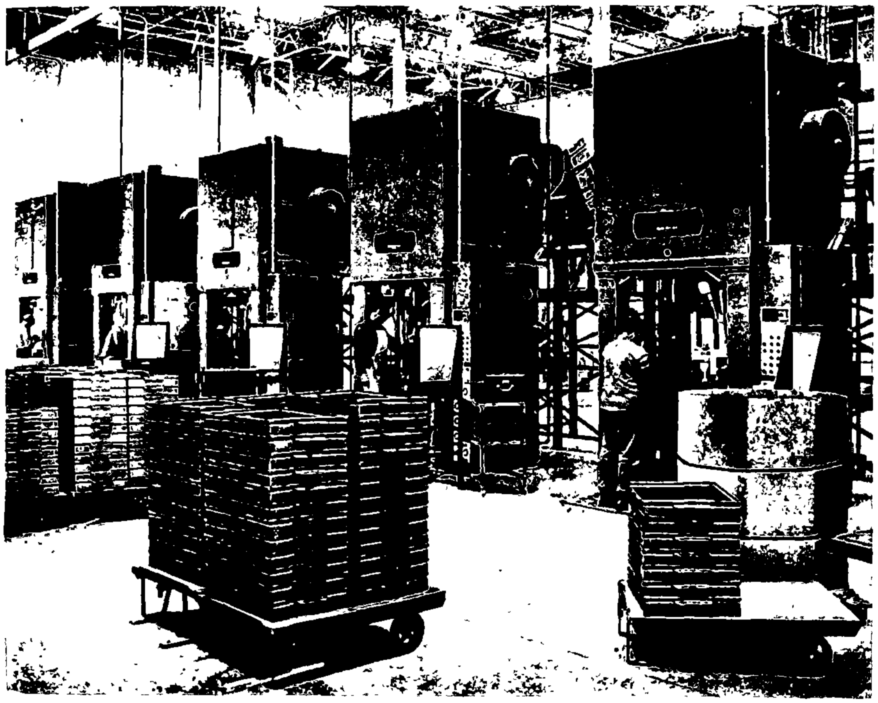
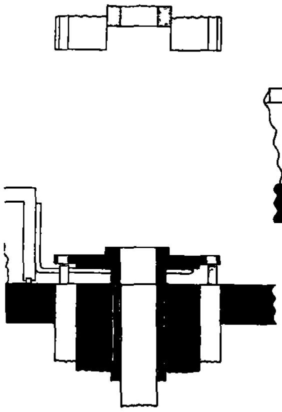
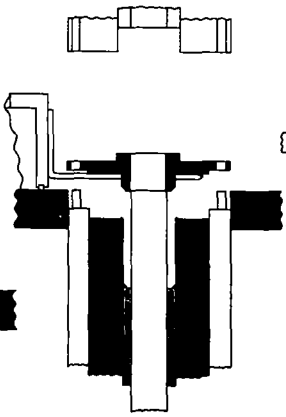


Fig. 3 Five of the new compacting presses are shown above just prior to installation of the rapistan gravity-feed roller conveyors that allow movement of parts from the presses to the sintering furnaces. Of the seven presses now in operation at the new plant, five are of 200-ton capacity and two of 500-ton capacity.

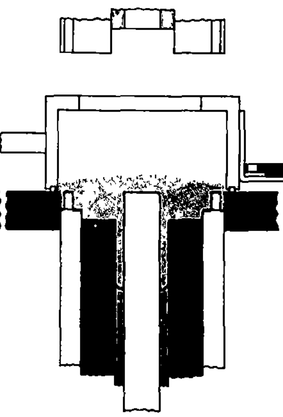




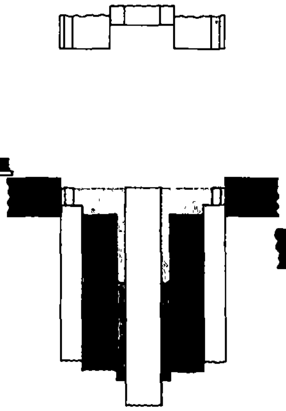
1. Feeder stroke delay dwells movement of shuttle feeder. Note the special pick up tool under compacted part flange.



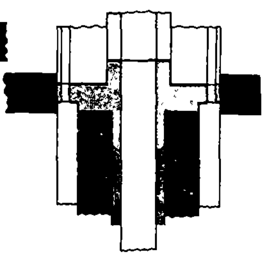
2. Part is removed while die members move into fill position.



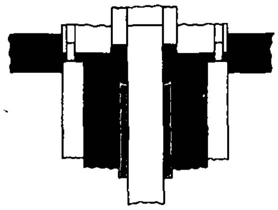
3. Shuttle feeder moves over die cavity to powder fill position.



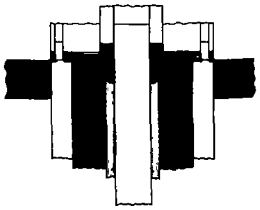
4. Underfill accessory moves die shell up.



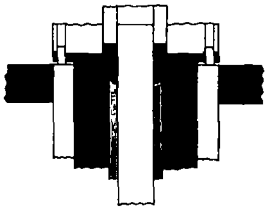
5. Reflex pressing action begins with powder transferred into dual upper punch accessory.



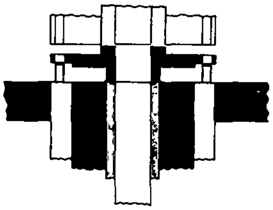
6. Part is fully pressed.



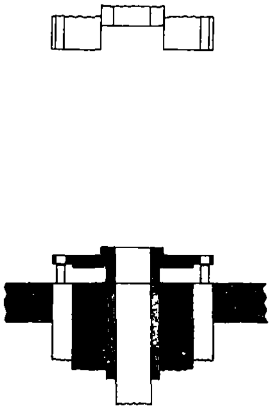
7. First Reflex ejection action begins.



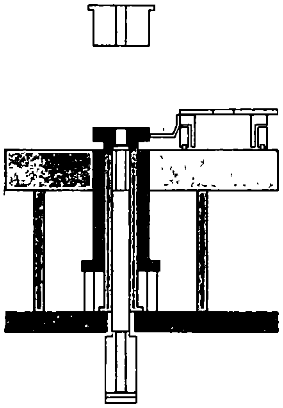
8. Reflex ejection continues.



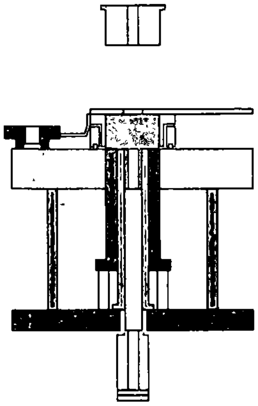
9. Reflex ejection continues.



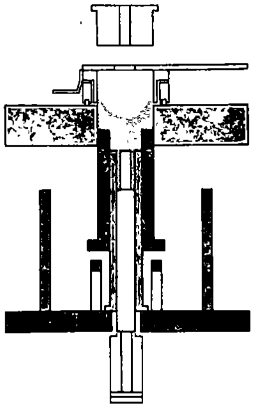
10. Ejected part ready for part pick up.



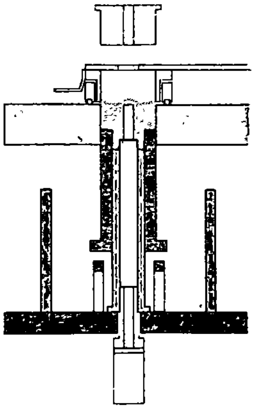
1. Shuttle feeder contacts pressed part as it begins moving into fill position.



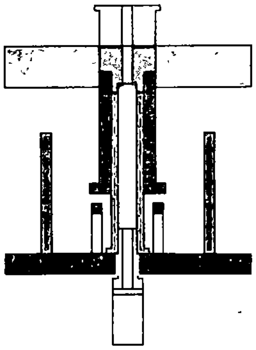
2. Shuttle feeder completes part ejection and is now in fill position over die.



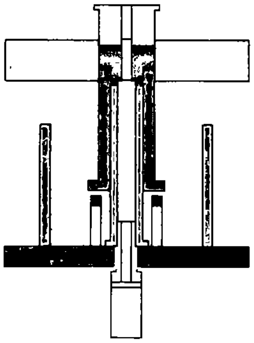
3. Tool components move into fill position thereby filling die cavity with powder.



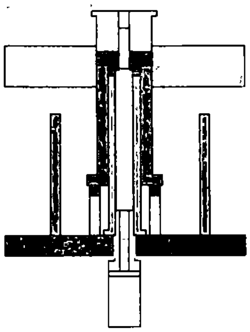
4. Floating core rod moves into fill position.



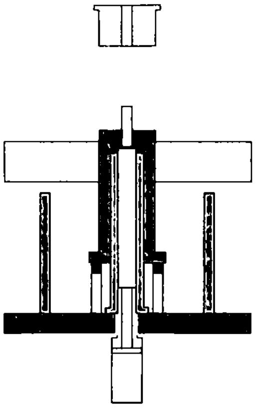
5. Feeder removes excess powder as it moves from die opening. Upper punch moves into pressing position.



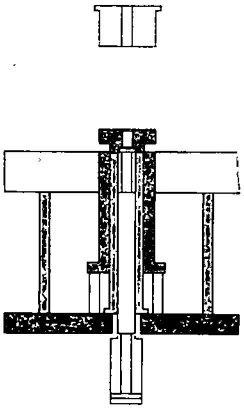
6. Reflex pressing motions begin.



7. Part fully pressed.



8. Reflex ejection is beginning.



9. Part fully ejected.

PM parts cut cost of locks

Converting from a stainless-steel investment casting to a powdered-metal part has generated a cost saving of 22% for a lock manufacturer

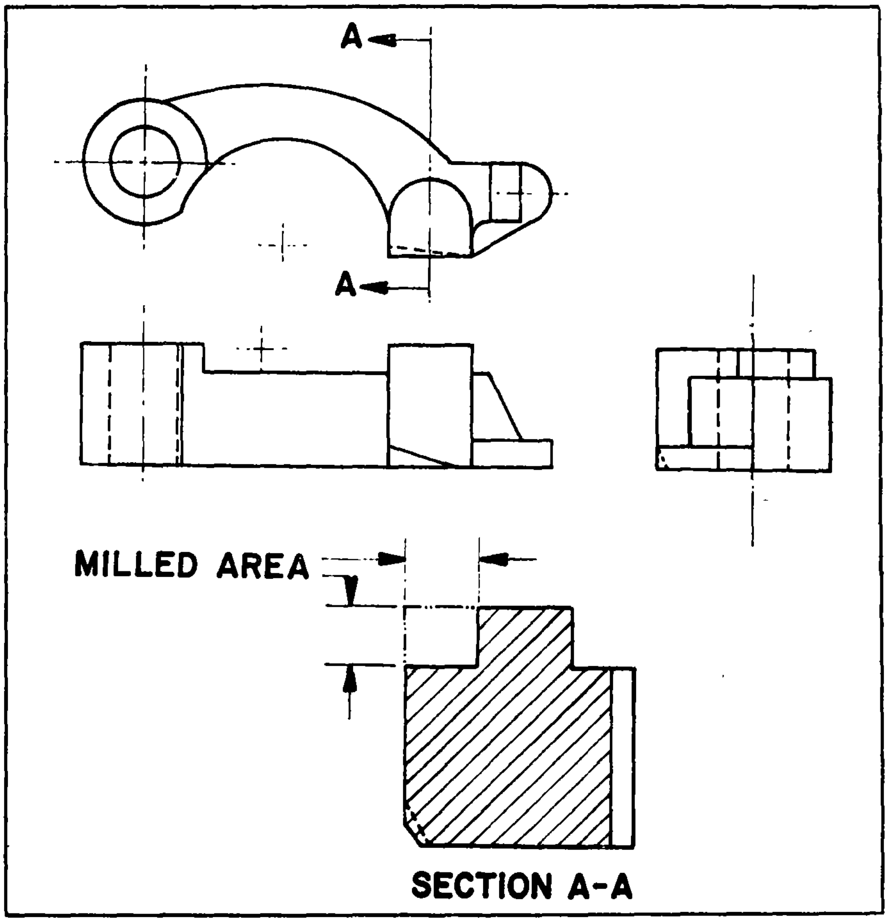
Latch levers for door locks are a good application for powder metallurgy, if the quantity is high enough to pay for the dies. This was the case recently when Sargent & Co. of New Haven, Conn., re-evaluated the design and production of its 8100 series of architectural mortise locks—which means door locks. Though stainless-steel investment castings were quite adequate when the locks were in early low-level production (investment castings being low in tooling cost, though fairly high in cost per unit), when production rates rose, a less costly manufacturing method had to be found.

The stainless steel (Type 303) required heat treating as a secondary operation. But the nickel-steel part now produced by powder metallurgy needs no heat treating. Further, the balance of strength with economy is better. The powdered steel has uniform and high density. Even higher strength is reached in a companion part, a lock hub, with a copper-infiltrated steel powder, allowing the part to withstand high torque when the lock is operated.

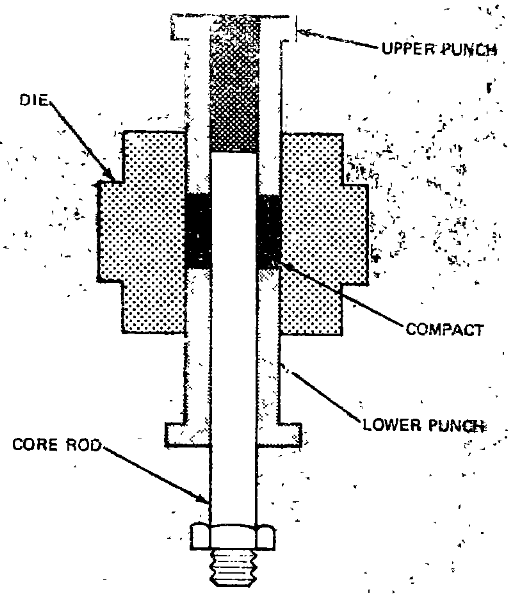
To avoid making two compacting die sets for two designs of latch levers in the same series, Sargent mills off a portion of the lever, thus using the same latch part for two applications.

The powder-metal parts, produced by Norwalk Powdered Metals, Inc., Norwalk, Conn., withstand abrasive sliding action in the lock, and for this reason must meet a specification of 72-80 on the Rockwell 15N scale. Test pieces have reached a million cycles in function tests, so the material is obviously strong and hard enough. The nickel-steel alloy is comparable to ASTM specification B-484, Grade I, Class A, Type II.■

Punch and die for compacting the latch levers are the only major tooling items required. After being compacted in a 40-ton press, these powder-metal parts are then sintered in an endothermic atmosphere at 2070 F



Basic latch lever is converted into an alternate type by a simple milling operation; thus only one compacting die set is needed for the two parts



1. COMPACTING tool set used to form a bushing from powdered metals.

◀ *TOOLS REQUIRED to produce the gear compact shown in foreground. The tools are upper and lower punches, core rod, and die with carbide insert.*

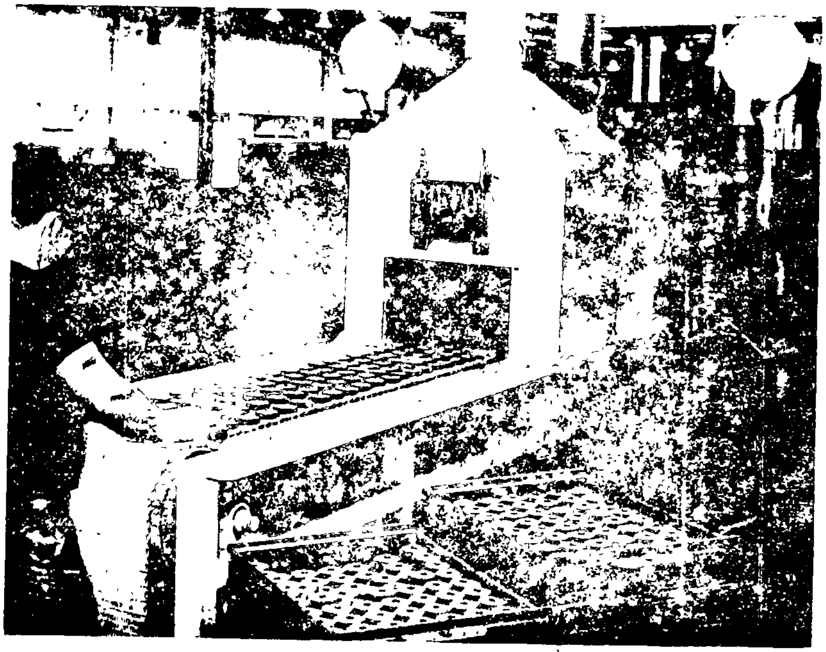
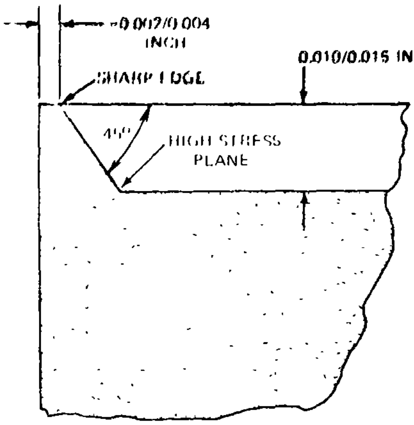
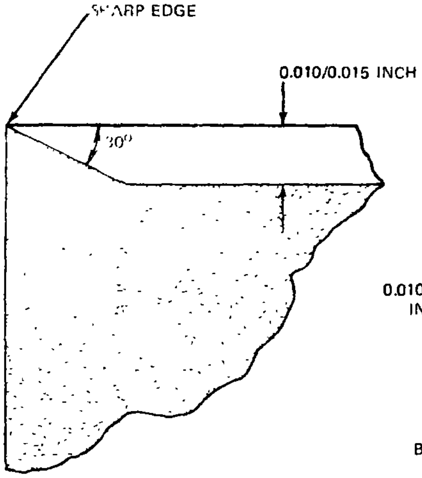


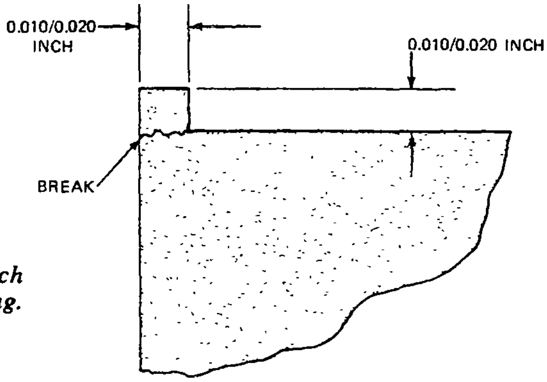
Fig. 5A View above shows preliminary loading of one of the five sintering furnaces that are 80 feet long. These new furnaces are able to handle 375 lb of powdered metal parts per hour, traveling on an 18-inch wide chromium-nickel conveyor belt that has a variable speed of from 20 ft per hour to 60 ft per hour.



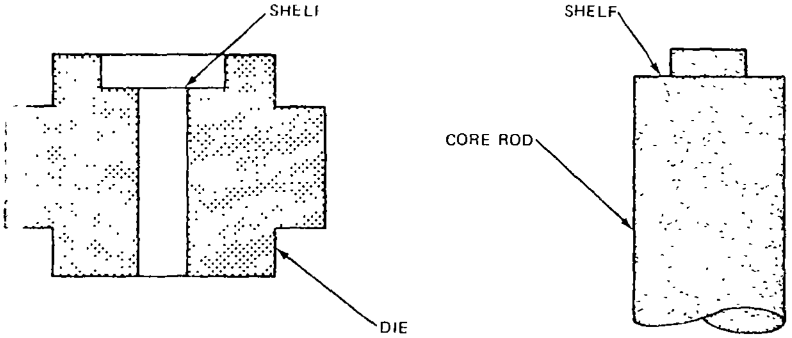
RAISED EDGE on punch forms a
to eliminate burrs on the compact.



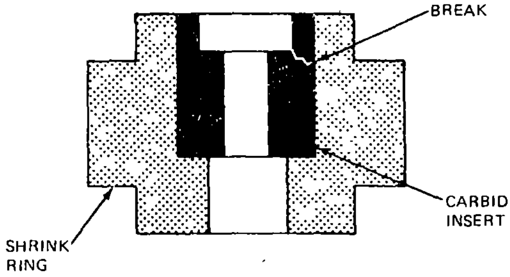
8. SHALLOW RAISED EDGE on punch helps reduce edge chipping and breaking.



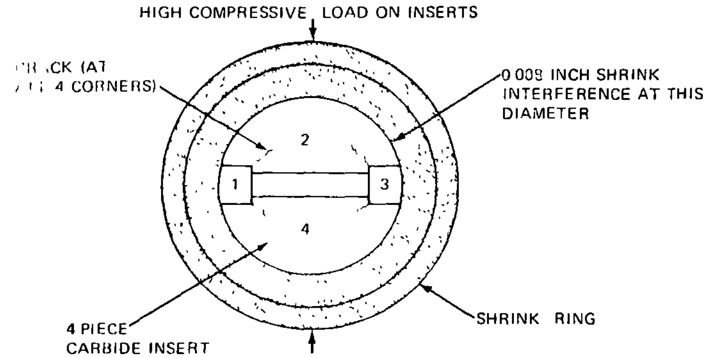
9. HIGH STRESS concentrations in this design cause excessive breaking and chipping.



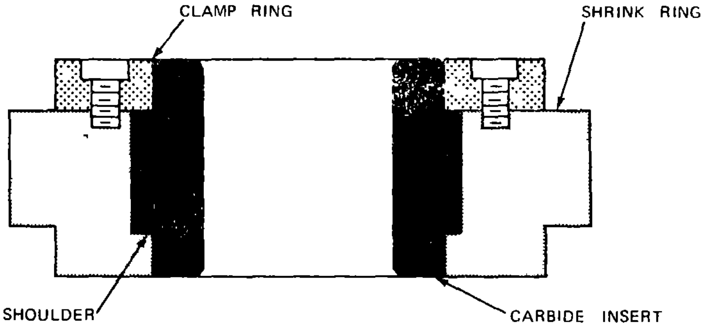
2. STRESS CONCENTRATIONS occur at tooling shelves used to form levels in the compact.



3. INSUFFICIENT SUPPORT of the die insert will lead to breakage at the tooling shelves.



4. CARBIDE DIE INSERTS cracked by the high stresses set up as the shrink ring cools.



5. CLAMP RING die construction used to prevent overstressing of the carbide insert.

Machinability of PM parts

It may be paradoxical, but machinability of PM parts can be important. Listen to what several researchers have found in measuring this property of PM materials

Although one of the advantages of powder-metallurgy materials is that they can eliminate machining in many instances, designs often call for secondary metalworking operations after the parts are pressed or forged. Among the design features that cannot be incorporated during conventional PM-pressing operations are radial holes, undercuts, and annular grooves.

The *Metals Handbook on Machining* lists 32 metalworking processes and their application to steel and cast iron. Of these, those that are most commonly used in the manufacture of finished sintered parts are listed below. And in the last section of this article, 'Cost-effectiveness of powder-metal manufacturing," there are four examples of parts that are produced by various machining operations:

Counterboring
Countersinking
Die threading
Drilling
Gear machining
Grinding
Honing

Tapping
Reaming
Roller burnishing
Spot facing
Tapping
Thread rolling
Turning

Machinability, therefore, can be a very real concern in PM-part production, and several studies have investigated the machinability of various PM materials. Two of the discussions that follow describe how such machinability can be measured; the third illustrates how cost-effective powder-metallurgy applications can be identified.

Defining machinability is as difficult when applied to powder metals as with other materials. One expert describes machinability as the response of a metal to machining. Another says it's a complex physical property of a metal that involves (1) true machinability, (2) finishability, or ease of obtaining a satisfactory finish, and (3) abrasiveness—the abrasion of the tool during cutting. A third expert summarizes: "From any standpoint, the material with the best machinability is the one that permits the fastest removal of chips with satisfactory tool life and surface finish."

However you define machinability, it still must be measured, and how this can be done is demonstrated here.

Drill-life tests

The number of inches drilled before tool failure—the basis of drill-life tests—reveals much about the machinability of PM materials. The test is relatively inexpensive, its results are generally reproducible, and the shape of the test part is not a factor.

The advantages of tool-life tests relate closely to the production shop since tool life is tied directly to tool-preparation costs and to machine downtime caused by toolchanging.

This discussion covers the machinability of the following materials: sintered iron-carbon, copper-infiltrated iron-carbon, low-alloy steel, and several types of stainless steel. Machinability tests performed on them showed good correlation between the material and such variables as microstructure, hardness, and porosity.

Several criteria are generally used in drill tests: (1) for varying conditions, the number of revolutions of a standard drill to make holes of a given depth; (2) for a hole of specific dimensions and for given machining conditions, the time to drill the hole; and (3) for a given set of machining conditions, the number of holes drilled before tool failure.

The third criterion, was used in the tests described herein. Machinability rating was determined by the number of inches of material removed by drilling in a press, under specified machining conditions, until failure occurred.

The drillpress that was used just for the tests was a 2-hp model, with close-tolerance bearings and a 3-jaw chuck. Speed was variable (160-5500 rpm), and mechanical feed per spindle revolution was 0.0025-0.010 in. It had forced lubrication of the spindle.

Each lot of test drills came from a single heat of high-speed-steel (M-1). Finish was UCW, hardness Rc 64.5-66.0, diameter nominally ¼ in., clearance regular, cutting tips straight, and the included point angle 118° (these are some of the main specifications). Coolant was a sulfurized, chlorinated mineral oil applied through three orifices at a constant rate of 2.5 gallons per minute.

The test procedure was based on a constant feed at 0.005 in./rev and a speed dependent on the test material. A minimum of three speeds were tried. Depth of drilling was governed by the shape of the part. If specimens are specially prepared for testing, 1-in. length is recommended, so that uniformly deep (¾-in.) blind holes can be made.

The end point of the test is usually catastrophic drill failure. It was found that this usually occurs after a wearland of about 0.015 in. has formed on the cutting edges.

Two methods may be used to interpret the test data. For a given drill life, the material using the highest drill speed would rate highest in machinability. Similarly, for a given drill speed, the material with the greatest number of inches drilled would rate highest in machinability. In either case, the relationship of one sintered PM material to another is essentially the same.

Five tests were performed

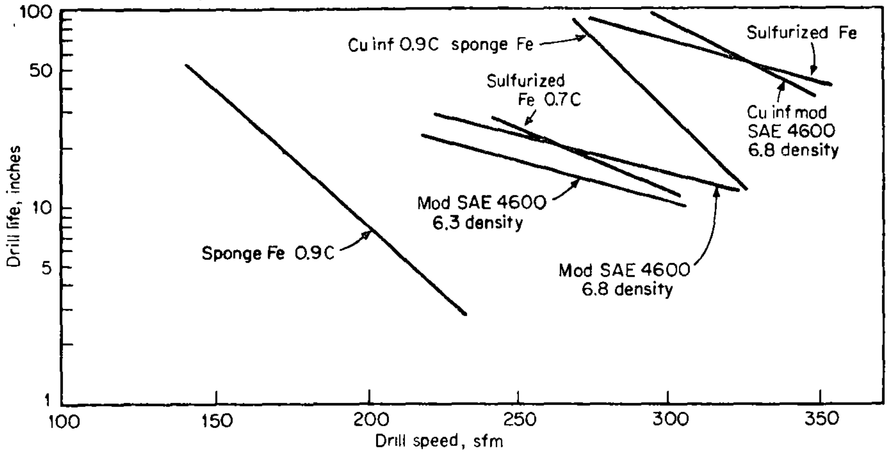
To rate the test data, statistical analysis was used to ensure that the results met specified probability limits. Fig 1 shows graphically the machinability of all the iron and low-alloy materials tested. Fig 2 shows the results of tests on sintered stainless steel. The graphs are summaries of machinability data from the five drill-life tests described below.

All of the materials in the following examples of drill-life testing were mechanically pressed and then sintered to obtain compacts of 1 in. dia x 1 in. long, nominally. Designations are those of the Metal Powder Industries Federation (MPIF).

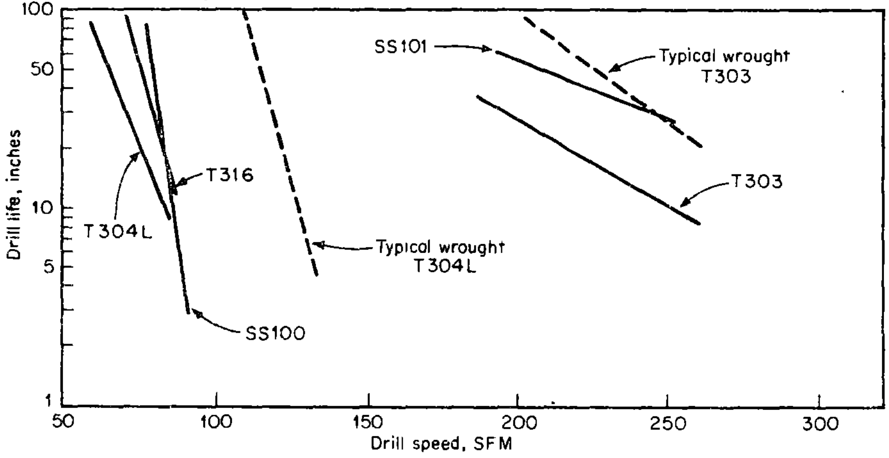
1. F-0008-P (0.88%-carbon sponge iron) and FX-2008-T (copper-infiltrated 0.88%-carbon sponge iron). Density of the former material was 6.27 g/cc; that of the latter was 7.38. The machinability plots in Fig 1 show that, with the increase in part density, the infiltrated sponge iron rated higher than the material in just the sintered condition.

2. F-0000-P-sulfurized and F-0008-P-sulfurized (0.04- and 0.72%-carbon sulfu-

1. Machinability of sintered ferrous materials



2. Machinability of sintered stainless steel



rized iron sintered to the same nominal densities). Here, the effect of the carbon addition is shown. The combined carbon results in much harder iron particles and, consequently, a considerable loss in machinability (drill life of 76.5 in. drops to 12.7 in. at the only common drill speed of 300 sfm). Another point: The machinability of the sulfurized iron containing 0.72% carbon can be compared directly with that of the sponge iron containing 0.88% carbon and low sulfur. The superior machinability of the sulfur-containing iron material is clearly demonstrated.

3. FN-0205-P-modified (0.5%-carbon-modified SAE4600 at 6.3- and 6.8-g/cc densities and after copper infiltrating the 6.8-g/cc compacts). In this case, involving a low-alloy steel, the elimination of pores—by simply increasing the density of the part—extends tool life. Note that the slopes for the Fig 1 plots for densities of 6.3 and 6.6 g/cc are about equal, but also note that drill life for the higher-density material is about 1.5 times as great as for the other. Copper infiltration, as might be expected, produces better machinability.

4. SS-304-R (AISI Type 304 stainless steel), SS-316-R (AISI Type 316 stainless steel), and IPM Grade SS-100 stainless steel. Machinability of these materials is plotted on Fig. 2, which summarizes all machinability-test data for the sintered austenitic stainless-steel compacts covered in this discussion. Typical test data for wrought Type 303 (sulfur-bearing) and Type 304 barstock are also shown. In general, machinability is not as good for parts with little or no alloy content. All show a similar porosity pattern in photomicrographs, and all samples were about the same density (near 6.5 g/cc). At higher cutting speeds, the graph shows that Types 304L and 316L possess better machinability, but, at slower drill speeds, the SS-100 material (a proprietary grade) exhibits the highest machinability rating.

5. SS-303-R (AISI Type 303 stainless steel) and IMP Grade SS-101 stainless steel. To improve the machinability of stainless steel, sulfur or selenium is added to the melt to produce compositions within the AISI Type 303 classifications. Of the two grades, sulfur-bearing Type 303 is produced in higher tonnages as wrought barstock. Note the much greater machinability of the Grade SS-101, a proprietary, free-machining grade made by IPM Corp. This material also has high corrosion resistance, in some applications equal to that of wrought Type 316L barstock.

From these tests, several conclusions were drawn. To get consistent results, the drillpress should have sufficient power for all conditions so as to maintain a uniform cutting speed for the particular drill size used and the material being tested.

Because they are of equal importance in obtaining consistent results, drills should be made to rigid standards. A drill was used only once in these tests: When it reached the end of its cutting life, it was discarded. It should also be emphasized that drills should come from a single heat of tool steel, with consistent response to heat treatment.

In these tests, the power needed to drill various materials also was measured, as an indication of machinability. Such measurements were found to be of little value, however. When abrasive materials were encountered, there was rapid tool wear with essentially no increase in power.

Cutting forces & additives

For the tests covered in this discussion, cutting forces are used as a basis of the machinability of PM parts. Specifically, they are the forces determined from drilling at constant feeds and speeds. Low forces are indicative of good machinability.

The significance of the tests lies in the effects of various additives in the powder blends—sulphur, lead, bismuth. Tests were also run on plastic-impregnated materials. Fig 7 shows the composition of the principal iron powders used in the tests.

In the tests, cutting forces during drilling were measured by two load cells positioned under the test specimen. The cells measured thrust and torque. Drilling conditions (on a drillpress) were as follows: 1160 rpm (76 sfm), feed of 0.005 in. per revolution, ¼-in. hss drill with 118° point angle, and 27° helix angle, and flood-cooled with a water-soluble oil. Depth of drilled hole was a nominal ½ in. After drilling tests, chips were examined to find out how the different additives affected the machining process.

Mechanical properties of the test materials were obtained from pressed-to-size tensile bars (Standard 10-63 of the Metal Powder Industries Federation). Compaction pressures were varied to maintain a sample density of 7 g/cc

7. Composition of iron powders used in this study

	%C	%Mn	%P	%S	%Si	$\%O_2$	%Fe
300M	0.01	0.12	0.008	0.018	0.022	0.15	Bal
400MS	0.01	0.21	0.020	0.156	0.024	0.15	Bal

8. Effect of plastic impregnation on drilling thrust

Alloy	Density (g/cc)		Thrust (lbs)		Thrust Reduction due to Impregnation (%)
	As Sintered	Sintered and Impregnated	As Sintered	Sintered and Impregnated	
300M	6.85	7.02	168	67	59
300M–.2%C	6.88	7.00	185	95	49
300M–.45%C	6.88	6.99	167	111	33
300M–.8%C	6.88	6.97	190	143	28

9. Effect of additives on tensile strength and ductility

Alloy	Density (g/cc)	Tensile strength (ksi)	Percent elongation
300M–.45C	6.93	33.7	10
400MS–.45C	6.95	33.9	8
300M–.8C	6.95	43.5	7
400MS–.8C	7.02	39.4	4.5
400MS–.8C–0.5Pb	6.96	38.8	4.5
400MS–.8C–1.0Pb	6.97	37.8	4
400MS–.8C–2.0Pb	6.96	39.9	5.7
400MS–.8C–2.0Bi	6.92	41.6	5
300M–.8C*	6.93	58.8	1.4
300M–.8C	7.03	57.9	1.4

* Plus plastic impregnation

10. Cutting force reductions: PM and wrought steels

Additive used	Percent thrust reduction	
	PM	Wrought
Sulfur	12–70	20
Lead	25–50 at densities = 7 g/cc	40
Bismuth	25–50 at densities = 7 g/cc	—
Plastic impregnation	28–59	—

decrease in strength as well as a reduction in ductility. Additions of lead and bismuth to the sulfurized steels have no effect on the properties tested. The data on the effect of plastic impregnation is taken from a paper by C.J. Landgraf, "Plastic Impregnation of PM Steels," (SAE paper 750952), presented in 1975. As the table (Fig. 9) shows, there is no significant change in tensile strength or percent elongation as a result of plastic impregnation.

For comparison purposes, in this entire study, wrought steels were tested. The table in Fig 10 shows thrust reductions obtained by the use of free-machining additives in both PM and wrought steels. Note that the reductions in thrust from use of both lead and sulfur are similar for both types of steels.

Cost-effectiveness of powder-metal manufacturing

The case-history approach shows whether PM parts will be viable in the marketplace by reason of cost effectiveness. The method is to estimate total demand, find the costs per piece and for tooling, compare piece cost with those of other processes, and then answer the question "Will the market accept a cost-effective innovation?"

When the factors are generally negative, as in the valve-body example (D), they should be reviewed periodically to see whether changing technology alters the evaluation (redesign, for instance, may eliminate secondary machining or sintering may reduce porosity and, thus, the need for plastic impregnation).

Ask the three questions

Three questions must be answered in an examination of the cost effectiveness of a particular part: (1) Are tooling methods optimum for the quantities produced? (2) Can a functional, reliable part be made by a lower-cost method? (3) Will the market accept a cost-effective innovation?

To get quantitative answers, four parts are analyzed here, using statistical data. The first step, however, is to obtain an answer to (3), above, for each part in question. Statistical information must be gathered and analyzed, and an estimate must be made as to the total demand for the assembled product using the part. After market demand is estimated, an assessment is feasible that tells whether tooling costs are justified, answering (1). And when costs for the most competitive alternate process are obtained, (2) is answered.

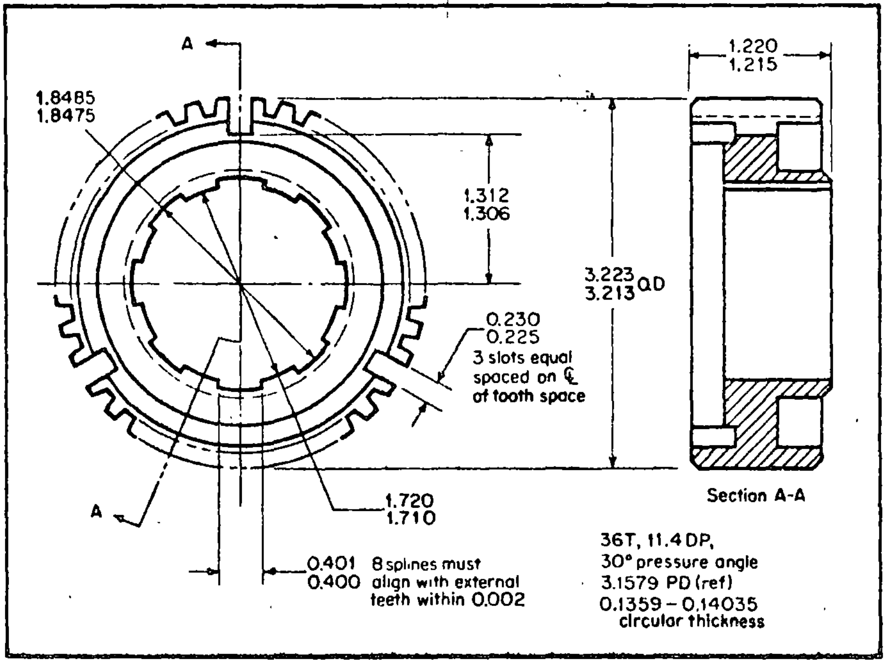
Which parts pass the test?

Example A, here, is cost-effective. The part in Example B, which is in an early stage of market acceptance, is only partly identifiable as being cost-effective. Example C shows only a theoretical cost-effectiveness but shows the importance of the market acceptance. Example D shows that the PM part is not cost-effective.

In each example, figures are based on an annual production of 500,000 parts; this allows fair comparison of process levels at which fixed costs can be considered equal between the two processes. PM costs are shown as a percent of those for machining, which are calculated to a base of 100. [Continued]

C. Automotive manual-transmission synchronizer hub

Weight. 1 0 lb. Concentricity, spline to centerline: 0.003 tir. Material: PM heat treated to Rc 30-35 (apparent) on spline ends. Wrought: Carburize, harden to Rc 40-44 on spline ends (0.040 case depth).

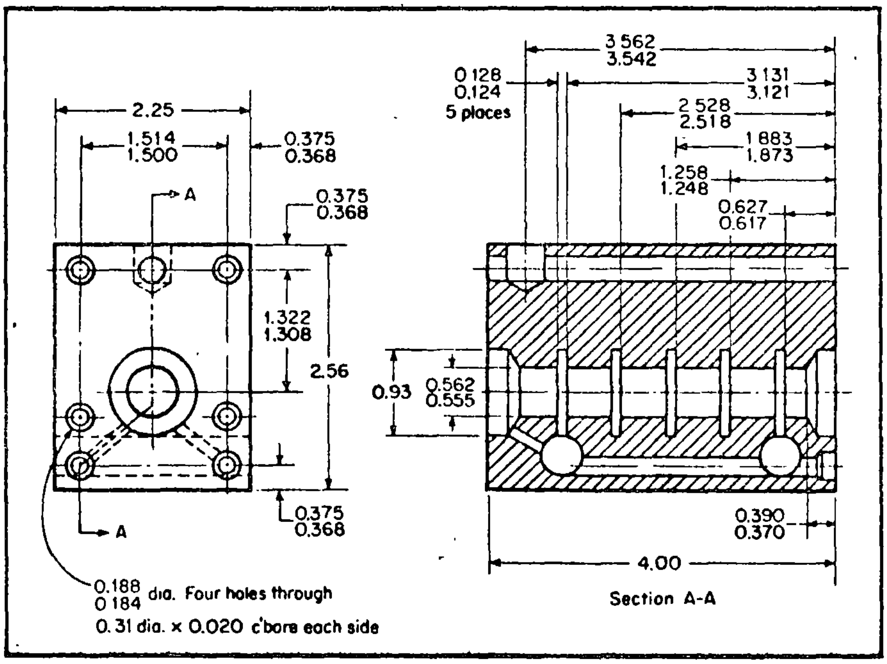


Machined hub	% of total	PM hub	% of Mach. total
86L20, incl cutoff stock, 65% chips, and 2% mfg scrap	33.28	Material: PMPA FN-0205-T (7 35 g/cc density), 5% scrap	13.49
Operations:		Operations:	
Bar chuck, turn end, bore ID, and cut off	21.41	Compact (500-T press)	8.01
		Presinter	2.57
Chuck & turn back face	6.85	Coat	0.30
		Coin (500 T)	5.35
Pot broach OD	17.80	Full sinter	3.08
Broach ID	7.11	Chuck and turn back face	6.85
Mill OD slots	4.28		
Carburize-harden	2.87	Harden	1.15
Deburr	0.64	Deburr	0.64
Inspect	0 32	Inspect	0.32
Perishable gages & tools, per 500,000 pcs.	5.44	Perishable gages & tools, per 500,000 pcs.	1 18
	100.00		42.94

Cost advantage: 57.06%

D. Fluid-power spindle-valve body

General tolerances (±): 0.005 internal port locations; 0.007 spindle passages (before grind), bolt hole ctrs. and porting hole ctrs. Material: PM braze-assembled and plastic-impreg. iron-copper-carbon. Machined type: 40,000 psi tens. strgth grey cast iron.



Machined body	% of total	PM body	% of Mach. total
Material:		Material:	
Grey cast iron; raw casting, incl 10% scrap	41.08	PMPA FC-0208-S (6.9 g/cc density) incl 5% mfg scrap & braze filler metal	49.54
Operations:		Operations	
Grind four sides	8.72	Compact (500 T)	
Finish bore, all ports	30.74	1st half	3.97
		2nd half	3.97
		Sinter & braze	3.18
		Plastic impreg.	15.37
		Cross drill	11.04
Ctrbore holes	6 65	Ctrbore holes	6.65
Cross drill	11.04	Grind one face	2.65
Deburr	0.53	Deburr	0.53
Inspect	0.40	Inspect	0.40
Perishable gages & tools, per 500,000 pcs	0 84	Perishable gages & tools, per 500,000 pcs.	5.30
	100.00		99.0

Cost advantage: 1.0%

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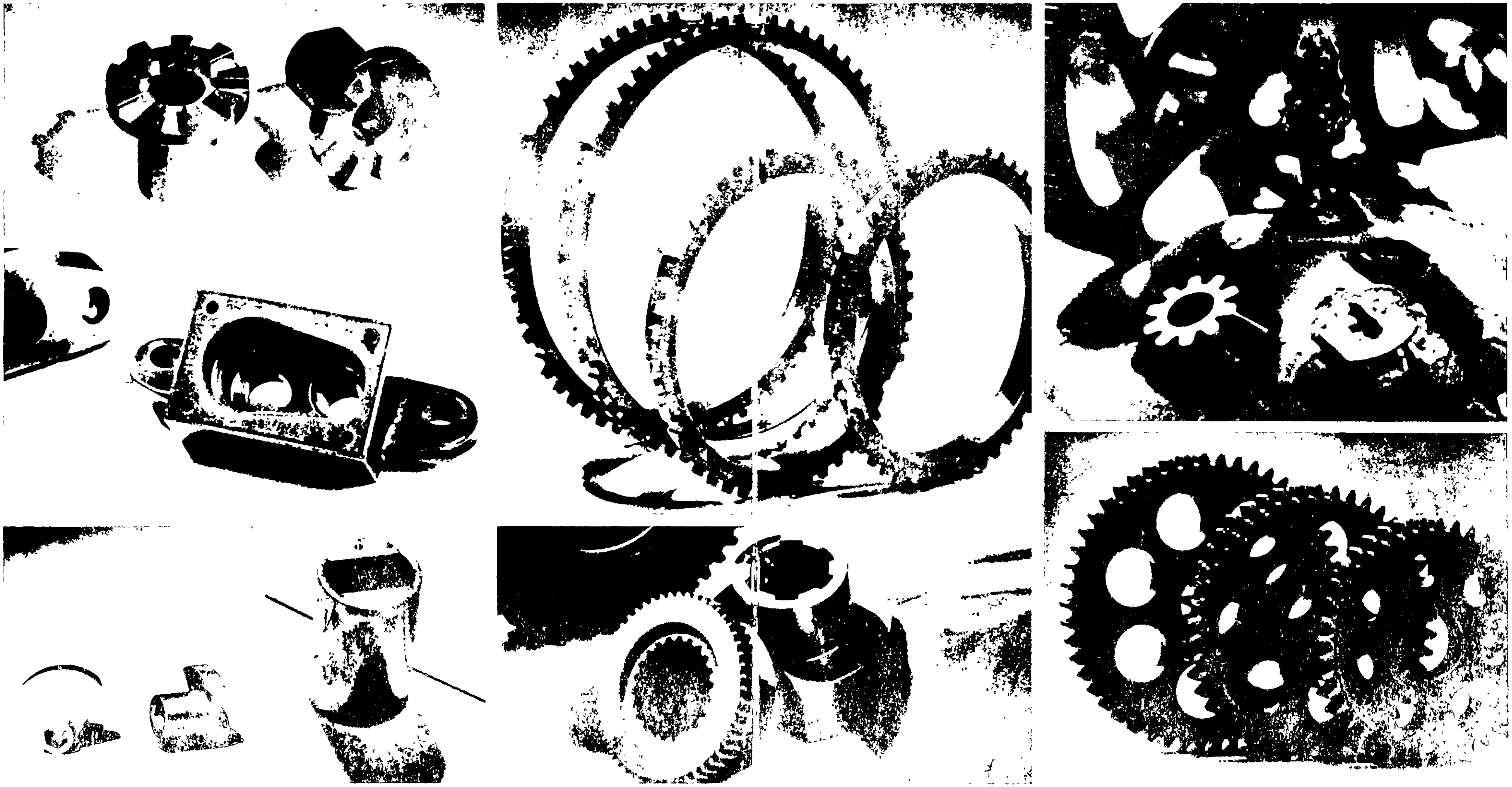
POWDER METALLURGY DESIGN GUIDEBOOK

FOR ENGINEERS · PRODUCT DESIGNERS
PURCHASING AGENTS · PROCESS PLANNERS



PUBLISHED BY THE METAL POWDER INDUSTRIES FEDERATION P.O. BOX 2054 · PRINCETON NEW JERSEY 08540

A Major Objective

of this Guidebook is to provide helpful and authoritative information for ready reference by designers, engineers, purchasing agents, and users of powder metallurgy parts. A better understanding of the process, its possibilities and advantages will lead to the more judicious selection and application of P/M parts.

Emphasis has been placed on proper design of the parts to permit most economical production coupled with optimum performance. Data is also presented on specifying, inspecting, and subsequent processing of powder metallurgy parts.

The Guidebook is published and distributed by the Metal Powder Industries Federation with the hope that it will aid in solving problems, economize in design and production time, and otherwise facilitate the proper application of P/M parts. Comments, criticisms and suggestions are invited.

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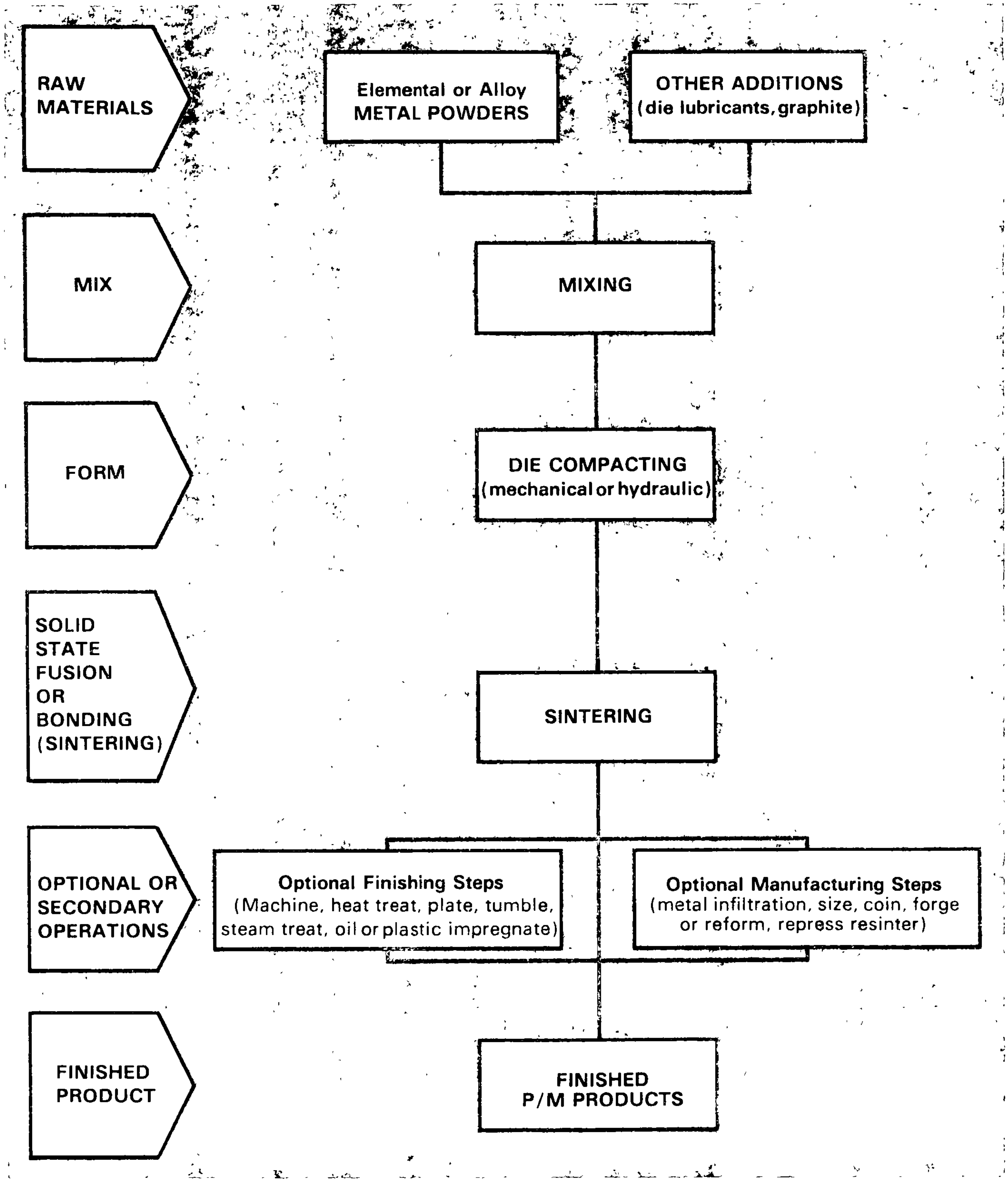
Figure 2


RAW MATERIALS
Elemental or Alloy METAL POWDERS
OTHER ADDITIONS (die lubricants, graphite)
MIX
MIXING
FORM
DIE COMPACTING (mechanical or hydraulic)
SOLID STATE FUSION OR BONDING (SINTERING)
SINTERING
OPTIONAL OR SECONDARY OPERATIONS
Optional Finishing Steps (Machine, heat treat, plate, tumble, steam treat, oil or plastic impregnate)
Optional Manufacturing Steps (metal infiltration, size, coin, forge or reform, repress resinter)
FINISHED PRODUCT
FINISHED P/M PRODUCTS

Powder metallurgy parts, commonly referred to as P/M parts, constitute one of the three basic forms in which metals are fabricated. They are produced by the powder metallurgy process, which involves blending of powders, pressing the mixture in a die, and then sintering or heating the compact in a controlled atmosphere to bond the particles into a strong shape. In contrast to the other two basic metal forms, P/M parts are shaped directly from powders whereas castings are formed from molten metal and wrought parts are shaped by plastic deformation of hot or cold metal or by machining.

Although metals in powder form have been used for a number of centuries, modern P/M technology came into its own during World War II, and since that time has been growing more rapidly than any other metal fabricating process Perhaps the principal reason for this rapid growth is that the P/M process is an economical, rapid, high production method for making parts exactly to or close to final dimensions and finish with little or no machining operations. When desirable, parts can be sized, coined or repressed to closer tolerances; they can be impregnated with oil or plastic or infiltrated with a lower melting metal; and they can be heat treated, plated and, when necessary, machined Production rates range from several hundred to several thousand per hour.

Shapes that can be fabricated in conventional P/M equipment range in weight up to about 35 lb. Parts of over 1,000 lb. can be produced with special techniques such as isostatic compacting and extrusion. However, most P/M parts weigh less than 5 lb. While many of the early P/M parts were simple shapes, such as bearings and washers, developments over the years in equipment and materials now make the production of more intricate and stronger parts economical Components with flanges, hubs, cores, counter-bores, and combinations of these are fairly commonplace.

As we shall see, P/M parts are made from a wide range of materials, including combinations not available in wrought or cast form. These materials can be processed by P/M techniques to provide tailored densities in parts ranging from porous components to high density structural and mechanical parts with properties comparable to or exceeding those of other metal forms. In addition, almost any conceivable alloy system under equilibrium or non-equilibrium conditions can be achieved, and segregation effects (non-homogeneities) are avoided or minimized

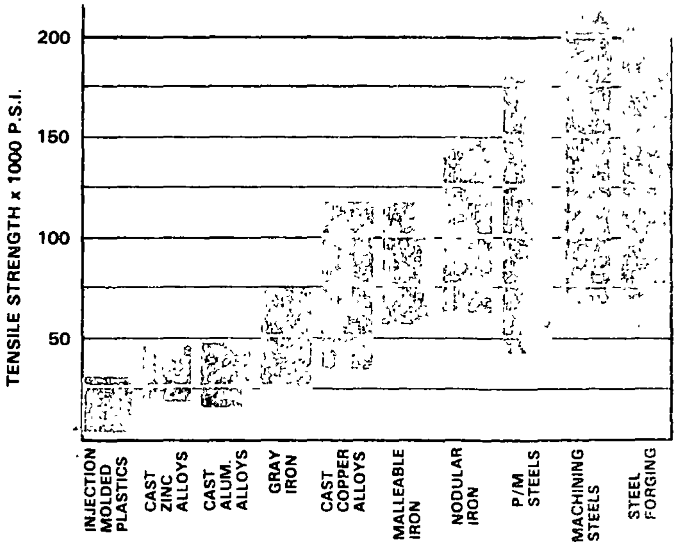
Because of its versatility, the P/M process is being used to produce many thousands of different parts in most product and equipment manufacturing industries, including automotive, business machines, aircraft, consumer products, electrical and electronic, agricultural equipment, machinery, ordnance and atomic energy.

The applications of P/M parts in these industries fall into two main groups. The first are those applications in which the part is impossible to make by any other method For example, parts made of refractory metals like tungsten and molybdenum or of materials such as tungsten carbide cannot be made efficiently by any other means. Porous bearings and many types of magnetic cores are exclusively products of the powder metallurgy process The second group of uses consists of mechanical and structural parts that compete with other types of metal forms such as machined parts, castings and forgings (Figure 1). This guidebook is primarily focused on the latter group.

In the following sections we will provide information on the process, the materials, performance properties and design that will define the capabilities of the P/M process and help you decide whether P/M parts can meet your requirements The following advantages of powder metallurgy will be covered in detail in the text:

- Machining is eliminated or reduced
- Materials (scrap) losses are eliminated or reduced
- Close dimensional tolerances can be maintained
- Almost any conceivable alloy system under equilibrium or non-equilibrium conditions can be achieved
- Good surface finishes are obtained
- Controlled permeability for filtration is available
- Complex or unique shapes, impractical with other metal forming processes can be designed
- Suited to high volume production of components

Figure 1



COMPARISON OF MATERIAL STRENGTHS

As stated earlier, the P/M process is primarily a rapid, high volume production method for making precision metal components. Typical parts can be produced at rates of several hundred to many thousand per hour. However, the process is not restricted to high volume production. The minimum run of parts that can be economically produced will be less under a number of conditions. These include simple parts requiring low original and maintenance tool costs, use of some or all of the tooling for more than one part, careful part design that is based on the use of the P/M process, minimizing secondary processing operations, and the number of machining operations that would be required if the part were produced by competitive methods. When these factors are considered, P/M parts often offer cost and performance advantages in runs as low as 1,000 or 1,500.

Primary Operations

There are three basic steps in the powder metallurgy process as shown in the flow diagram (Figure 2). Elemental metal powders or alloys are blended together with lubricants or other alloy additions to produce a homogenous mix of ingredients. This blending operation is performed either by the metal powder supplier or by the P/M parts producer.

Compacting

In the next step a controlled amount of blended powder is automatically fed into a precision die and compacted or pressed, usually at room temperature at pressures as low as 10 tons per sq. in. or as high as 60 or more tons per sq. in. (138 to 827 N/mm^2).

The compaction operation consolidates and densifies the loose powder into a shape commonly termed a green compact. With conventional pressing techniques, the compact has the size and shape of the finished part when ejected from the die. It has sufficient strength for in-process handling and transport to the furnace. The most widely used compacting techniques involve rigid dies and special mechanical or hydraulic presses.

Dies and tools, made of either hardened steel and/or carbides, consist of at least a die body or mold, an upper punch, a lower punch, and in some cases one or more core rods. A typical set of tools for producing a straight cylindrical part, such as a sleeve bearing is shown in Figure 3. The pressing cycle for this simple part, illustrated in Figure 4, is as follows: 1) The empty die cavity is filled with blended powder. 2) Both top and bottom punches simultaneously press the metal powder in the die. 3) The top punch is withdrawn and the green compact is ejected from the die by the bottom punch. 4) The green compact is pushed out of the pressing area to make ready for another operating cycle.

In general, this compacting cycle is essentially the same for all parts. However, when more than one pressing level is needed, as for example in producing flanged shapes, multiple punches are used and separate actions may be required. Holes in the direction of pressing can be molded by using additional core rods.

Other forming methods are sometimes used, including isostatic pressing, high-energy rate forming, forging, extrusion, and slip casting.

Sintering

In the third step, sintering, the green compact is heated in a protective atmosphere furnace to a relatively high temperature, but below the melting point of the metal. Sintering, which is mainly a solid state process, develops metallurgical bonds among the powder particles and thus produces the P/M part's mechanical and physical properties.

Secondary Operations

For many applications, after sintering, P/M parts are ready for use. However, any one or more secondary operations can be applied to provide specific or special properties. Parts can be repressed, they can be infiltrated or impregnated, or they can be modified by such conventional operations as machining, tumbling, plating and heat treatment.

Repressing (Coining) (Sizing)

A second pressing operation may be needed to provide certain characteristics. Using high pressures a sintered metal part may be further reduced in volume to increase its density, thus improving certain properties such as strength and part-to-part dimensional consistency. Repressing can also be used to produce more complex shapes not possible in a single pressed part, or to reshape or emboss the surface.

Impregnation and Infiltration

The controlled porosity in P/M parts makes it possible to infiltrate them with another metal or impregnate them with oil or a resin to either improve mechanical properties or to provide additional performance characteristics (see Figure 5). Also by suitable compaction techniques, porosity can be made to differ from one portion of a part to another.

The oil impregnated P/M bearing, which has been used in automobiles since the late Twenties, is one of the best known examples of the use of impregnation. Conventional P/M bearings can hold from 10 to 30% oil by volume. Generally, additive free oils (non-automotive engine oils) are used. Impregnation is done by soaking the parts in heated oil for a period of time or by vacuum techniques. During use, when the part heats up from friction, the oil expands and flows to the bearing surface. Upon cooling, the oil returns into the metal mass by capillary action.

By infiltrating P/M parts with another metal, mechanical properties can be greatly increased. In the operation, slugs of infiltrant, which have a lower melting point than the porous bodies, are placed on the compacts during sintering. Upon melting, the infiltrant is completely absorbed as a liquid into the pores by capillary action to produce a component with a composite structure. The resulting properties generally depend upon the metals which constitute the structure of the infiltrated part, together with the way and proportions in which they are combined. Besides improving mechanical properties, infiltration is used to seal pores in preparation for electroplating, for improving machinability and for making parts gas or liquid tight.

Heat Treating

P/M parts can be annealed, quench-hardened and surface-hardened similar to wrought products. Because of the porosity, greater care must be taken to maintain a neutral and dry atmosphere. While high density (7.2 g/cm^3 min.) and infiltrated steel parts can be heat-treated by conventional methods, lower density parts should not be subjected to

Figure 3

Typical set of tools

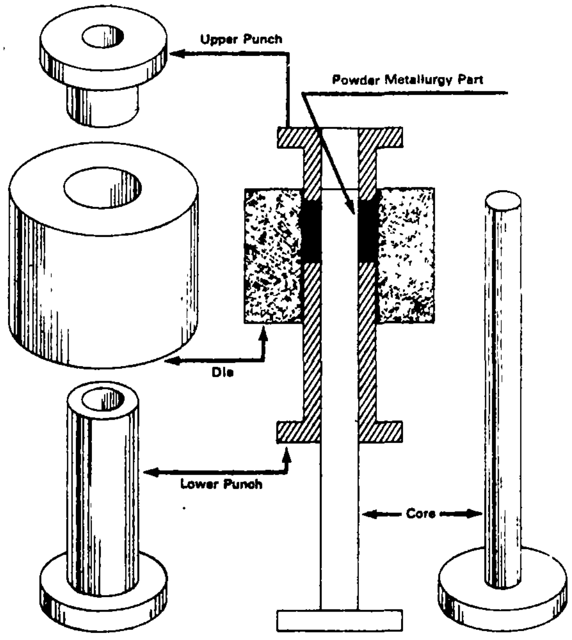
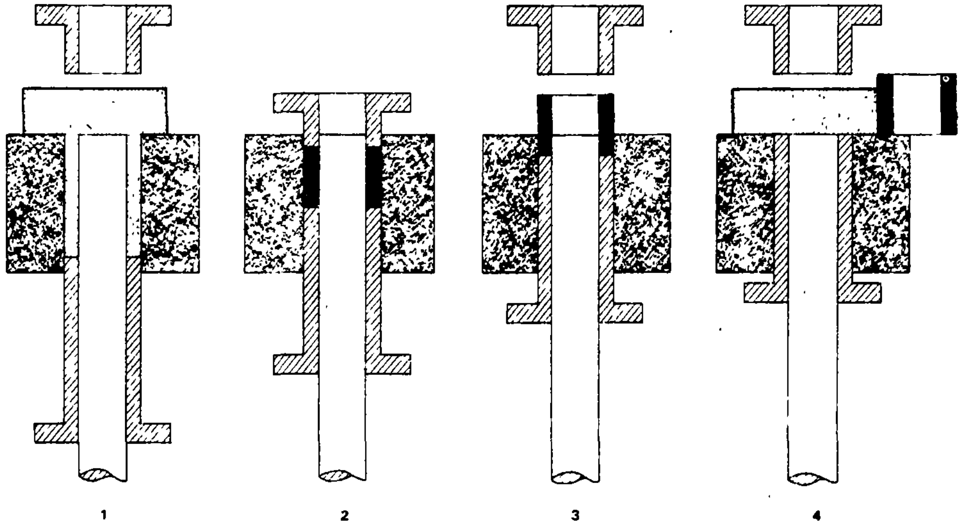


Figure 4

Pressing Cycle



liquids, such as carburizing salts, brine or water, which can become entrapped within the part and cause corrosion. In general, oil should be used as a quenching medium for low density parts.

Carburizing and carbonitriding are commonly used for surface hardening ferrous P/M parts. Depth of case depends, of course, on the carburizing medium, time and temperature. With high density parts, a well defined case is obtained. However, with lower density parts, carbon diffuses more rapidly and to a greater depth, resulting in either through carburization or an apparent case of indefinite thickness.

Machining

Although P/M parts are normally produced to finished dimensions, machining can be used to produce special shapes and holes and to achieve closer tolerances. The machining characteristics of P/M parts are similar to cast products. However, materials can be added readily to the powder mix to improve machinability. Small additions of lead, sulfur, copper, or graphite are common in ferrous parts, and lead is frequently added to nonferrous parts. Oil or resin impregnation also improves machinability of all porous P/M parts.

Certain basic guidelines apply to all types of machining operations performed on P/M parts. Machining feeds and speeds for high density parts (above 92% of theoretical density) are similar to those for wrought metals. Lower density parts require adjustment of feed and speed to obtain optimum results. When machining porous bearings or other porous parts, intended to be self-lubricating, special care must be taken to avoid smearing the surface porosity. In single point machining, such as turning or boring, use of sharp tools and light cuts helps maintain surface porosity. While lubricants are preferred for most machining operations, tendency for lubricant pick-up by parts increases with increased porosity. All machining except grinding should be done before tumbling, because retained tumbling abrasives can cause excessive tool wear.

Below, some suggestions are given for various machining operations, but it should be noted that they do not necessarily apply to all cases.

Turning — Sharp pointed, carbide tools are recommended. Cutting angles on single point tools should be 15 deg., back rake about 10 deg., and reliefs about 10 deg. Cutting speeds of 175 to 350 sfpm (0.8 to 0.2 m/s) and feeds of 0.002 in. to 0.004 in. (0.05 to 0.10 mm) are normally used. When smearing of surface porosity must be avoided, slower speeds (100 to 150 sfpm) (0.5 to 0.75 m/s) lower depth of cut (0.002 in.) (0.05 mm), and very sharp tools are used.

Milling — Cutters of high speed steel, cobalt steels and carbide are recommended. Helical cutters with axial rake are preferred so that chips are sheared on an angle. Recommended speeds are 70 sfpm for high speed steels and up to 300 sfpm for carbide tools. Each should be 0.002 to 0.005 in. (0.05 to 0.13 mm) per tooth for roughing and 0.001 to 0.002 in. (0.03 to 0.05 mm) per tooth for finishing.

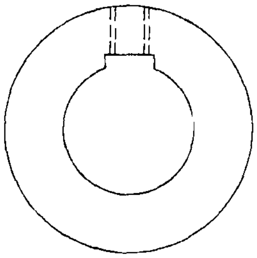
Drilling and Tapping — In general, speeds and feeds used for drilling P/M parts are slightly lower (about 80 to 85%) than those used on wrought metals of the same composition. Nitrided steel, cobalt steels and carbide tipped drills are recommended for long life. When holes in the direction of pressing must

Figure 5

Oil Impregnation

Figure 6

Burr Relief Slot



be drilled, they can be spotted, partially formed or chamferred in pressing the part, therefore simplifying the drilling operation. Internal threads are produced by conventional tapping methods. Premium grade steel or nitrided taps give excellent life. Roll form tapping is also used. A design advantage of the P/M process is that a burr relief slot can be provided, as shown in Figure 6.

Grinding — Grinding operations similar to those used on wrought products are applicable to P/M parts. However, where surface porosity is required, grinding tends to reduce or close porosity. Coolants should contain rust inhibitors. Magnetic chucking does not hold low density parts as well as wrought parts.

Finishing

Practically all common finishing methods are applicable to P/M parts. While in many applications procedures are about the same as for wrought and cast parts, the structural characteristics and porosity, particularly in low density parts, require some modifications in finishing operations.

Tumbling — In this process, which is used for cleaning, deburring, shine rolling or burnishing, P/M parts are rolled in rotating barrels or agitated in vibrating tubs usually with some form of abrasive media and water. Rust inhibitors should be added to the water. After the operation parts may be spun dry; in addition heat should be used to evaporate water from the pores. Also, parts can be resin or oil impregnated before tumbling to eliminate the possibility of water absorption during tumbling. Tumbling should be done after machining to avoid abrasive pick-up in the pores that might lead to excessive tool wear. Also, care should be taken to avoid residual abrasives on parts where this carry-over could be detrimental to operations of parts in service.

Burnishing — Burnishing can be used to improve part finish and dimensional accuracy, or to work-harden surfaces. Common burnishing techniques are tumbling, roller burnishing, ball sizing, and stick burnishing using a broach-like tool with buttons or ridges on it. Compared to burnishing wrought parts, closer tolerances can be held on most P/M parts because surface porosity allows metal to be displaced more easily. As with machining, in some cases care must be taken to avoid closing of surface porosity.

Blueing (Blackening) — Ferrous P/M parts can be colored by several methods. To give parts light indoor corrosion resistance, they can be blackened by heating in a furnace to the blueing temperature and then cooled. Oil dipping gives a deeper color as well as slightly more corrosion resistance. When oil dipping, a dry-to-touch oil may be used, which leaves a dry film on the parts.

Ferrous P/M parts can also be blackened chemically, using one of several commercial liquid salt baths. If parts are below a density of 7.3 g/cm^3, care must be taken to prevent salt being entrapped in the pores. To avoid this possibility, parts can be impregnated, prior to blackening, with a resin that will not break down in the bath. Nickel-bearing and copper-bearing parts tend to adversely affect most blackening baths. Also, these materials seriously affect color of the part. As is the case with furnace blackening, an oil dip gives better appearance and corrosion resistance.

Steam treating is another process which provides increased corrosion resistance for ferrous P/M parts. The blue-black iron oxide formed in this process also affects other characteristics. By filling some of the interconnecting porosity and much of the surface, the P/M part density is increased, leading to higher compressive strength. Furthermore, the oxide coating provides additional hardness and wear resistance. At the same time, the process tends to cause a slight size change and to make the parts more brittle and more difficult to machine. The treatment involves heating parts to 750-1100F. (400-600 C) and exposing them to super-heated steam under pressure. Usually parts are oil dipped after cooling to further increase corrosion and wear resistance, and to enhance appearance. Heat-treated parts are seldom steam-treated, because the treatment anneals them.

Plating — All types of plating in general use, including copper, nickel, chromium, cadmium and zinc, can be applied on P/M parts. High density (7.2 g/cm^3) and infiltrated parts can be plated using the same methods as on wrought parts. Lower density parts should have porosity sealed to avoid entrapment of plating solutions in the pores. Resin impregnation is normally used for this purpose. Parts that have been oil impregnated or quenched in oil, must have all oil removed from the pores and surface prior to resin impregnation and/or plating. Electroless nickel plating can also be used, and peen (mechanical) plating is applicable to non-impregnated ferrous parts in the 6.6 to 7.2 g/cm^3 density range.

Taken together, the basic powder metallurgy steps and the optional secondary operations just described provide a versatile process in which variables can be adjusted to produce parts with controllable porosities or with densities approaching those of conventional cast and wrought products. In addition, this versatility affords a range of properties and finishes not possible with other metal fabricating methods.

Metal powders are highly engineered materials. The availability of numerous types and grades designed for P/M makes possible the production of P/M parts to meet a wide range of performance requirements.

Most metal powders are produced by atomization, reduction of oxides, electrolysis, or chemical reduction. Metals available include iron, tin, lead, nickel, copper and aluminum, as well as refractory and reactive metals. These metals can be mixed together to produce different alloy compositions during sintering. Also, prealloyed powders, such as low-alloy steels, bronze, brass, nickel silver, and stainless steel powders are produced in which each particle is itself an alloy. It is possible to combine metal and nonmetal powders to provide composite materials with the desirable properties of both in the finished part, a characteristic unique to P/M.

Limited space permits coverage here of only the major types of P/M materials commonly used for structural parts and bearings, most of which are covered by MPIF Standard No. 35. This standard provides information for specifying those P/M materials that have been developed and accepted by the parts manufacturing industry as standard and representative of their capabilities and commercial practices. A chart from Materials Standard 35 shows property bands (Figure 7).

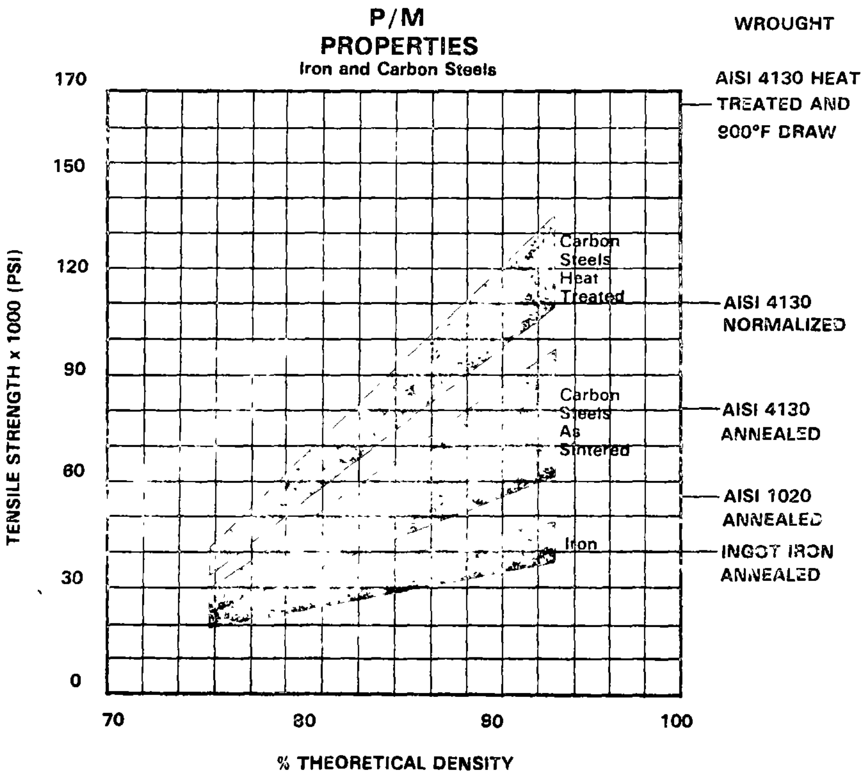
The physical characteristics of powders are related to the way in which they are processed and also influence the properties of the finished P/M part. These characteristics are controlled largely by the metal powder producer and the method of production. They include: particle size and shape, and size distribution or sieve analysis; apparent or bulk density of the unpressed powder; rate of powder flow into the die cavity; powder compressibility in the die; in addition to a variety of other properties and characteristics which are important to the manufacture of acceptable P/M parts.

Ferrous Materials

Iron powders are the most widely used P/M material for structural parts. While iron powder is used alone in some cases, most frequently small additions of other powders, such as carbon, copper or nickel, are added singly or in combination to improve mechanical properties of the pressed and sintered part.

Carbon Steel — Plain carbon steels covered by MPIF Standard 35 are made from mixtures of iron and graphite. When the parts are sintered, carburization results to produce a carbon steel structure with carbon content that can range up to about 0.75%.

Figure 7



Low, medium and high density parts can be produced from these powders, giving a range in tensile strength from 16,000 to almost 60,000 psi (110-413 N/mm^2). By heat treatment, strengths can be increased to over 90,000 psi (620 N/mm^2). Prealloyed low carbon steel is also available.

Copper Steel — Adding copper to iron powder increases strength, and tends to increase hardness. Copper, however, makes parts less ductile. The copper steels covered in MPIF Standard 35 contain from 1.5 to 10.5% copper and up to 1.0% carbon. Low, medium and high density parts, and bearings are produced with these powders. Tensile strength ranges from 20,000 to more than 80,000 psi (138-552 N/mm^2). Heat-treated parts have strengths of up to 100,000 psi (689 N/mm^2).

Nickel Steel — Nickel in the order of 2 to 8%, with or without copper, can be used with iron powders to obtain exceptionally high strength parts along with improved toughness and fatigue strength. Strengths of between 90,000 and 100,000 psi (621-690 N/mm^2) can be achieved in nonheat-treated parts. Heat treatment increases strength to as high as 180,000 psi (1241 N/mm^2).

Stainless Steels — Stainless steels have been successfully used in a broad range of applications, including automotive, appliance, hardware, marine and food industry parts and porous filters. Although more costly than iron base powders, their use is justified where good strength combined with high corrosion resistance is needed.

Other Steels — A number of other steel powders are available for P/M parts. For example, prealloyed low-alloy nickel and molybedenum steels are seeing wide use for parts that are heat-treated to provide improved mechanical properties.

Infiltrated Iron — Porous ferrous parts can be infiltrated with several lower melting materials, such as copper and various brasses. Copper infiltrated parts, the most commonly used, are covered in MPIF Standard 35. Copper content in the finished parts ranges from about 8 to 25%, reducing residual porosity to virtually zero. Standard copper infiltrated parts have as-sintered tensile strengths ranging from about 65,000 to 90,000 psi (448-621 N/mm^2). Heat treatment provides strengths up to 130,000 psi (896 N/mm^2). Besides improving strength, infiltration is also used to obtain uniform density in parts that are difficult to press to uniform density.

Copper Base Materials

Besides copper, there are other compositions of copper alloy powders available, including the brasses, bronzes and nickel silver. Pure copper is used primarily for parts in which high electrical and/or thermal conductivity is specified.

Nickel Silver — Metals commonly called nickel silver are copper-nickel-zinc prealloyed powders containing between 16 and 19% nickel. Parts made of these powders have properties similar to those of brass and somewhat better corrosion resistance.

Aluminum Materials

There are several aluminum alloy powders being used for P/M structural parts and bearings. The major alloying elements include copper and magnesium. Aluminum P/M parts offer good corrosion resistance, light weight, good electrical and thermal conductivity. Tensile strengths range from about 15,000 to 50,000 psi (103-345 N/mm^2) depending on composition, density and heat treatment.

Brass — Prealloyed brass products are available in a wide range of compositions, with zinc content running from about 10% to as high as 30%. MPIF Standard 35 covers leaded brass with copper content ranging from 77 to 80% and lead from 1 to 2%. Sintered brass parts have tensile strengths up to 40,000 psi (276 N/mm^2). In machinability they are comparable to cast and wrought brass stock of the same composition. Brass P/M parts are well suited for applications requiring good corrosion resistance, good machinability, attractive appearance, and ductility.

Bronze — Oil impregnated self lubricating bronze bearings are the most widely used product of non-ferrous P/M materials. They are made from mixtures of elemental copper and tin powders. During manufacture, the bearing density is closely controlled in order to provide between 18 to 30% interconnecting porosity to serve as an oil reservoir. Bronze bearings have tensile strengths of 8,000 to 18,000 psi (55 to 125 N/mm^2). High strength bronze structural parts with tensile strengths up to 50,000 psi (350 N/mm^2) are usually made from prealloyed bronze powders.

Magnetic Materials

P/M is used for many soft magnetic applications. The most important properties for good permeability are purity and density. Because of porosity, sintered "soft" magnets show lower flux densities than wrought magnets of the same size and shape. This may be overcome by designing magnetic parts somewhat larger. Cost of the small additional amount of material is usually more than offset by the fact that with the P/M process there is virtually no scrap. Below, the various types of powder for soft magnetic parts are briefly characterized.

Low-Density Iron — It is the least expensive magnetic material and is characterized by a wide hysteresis loop with a low Bmax and high Hc.

High-Density Iron — A better soft magnetic material, the higher density gives a higher Bmax and a lower Hc resulting in less core losses. Characteristics approach wrought iron.

Silicon Irons — Normally used in applications where higher electrical resistivity results in lower core losses and fast magnetic response. These materials have a flux density (Bmax) somewhat lower than (Hc) and considerably higher permeability (μ).

Nickel Iron — This material is used for fast magnetic response for minimum applied field. It has the fastest rise in permeability of any P/M material. It is generally made from 50/50 prealloyed powder and has low coercivity (Hc).

Hard Magnetic Materials — Permanent magnets such as Alnico are also produced by the P/M process but are not considered in this design manual.

Other Materials

Other P/M materials such as cemented carbides, heavy metals, dispersion strengthened materials, composites, friction materials and superalloys are also not covered in this publication.

As we have just seen, there is a wide range of powder metallurgy materials to choose from to meet the service requirements of a particular application. This section will provide a broad survey of the engineering properties of P/M parts made from these materials. We will not present large quantities of detailed property information, but rather only representative data. For more specific and detailed data, it is best to obtain it directly from original sources, specifications or P/M parts producers.

Density — Most properties of a P/M part are closely related to its final density. This density is the weight per unit volume of the part expressed in grams per cubic centimeter (g/cm^3). Normally, density of mechanical and structural parts is reported on a dry unimpregnated basis, while density of bearings is reported on a fully oil impregnated basis. Density may be calculated by any of several means. A commonly used method is given in MPIF Standard 42.

Density is also expressed as percent of theoretical density, which is defined as the ratio of a P/M part's density to that of its wrought metal counterpart. In practice, P/M parts that are less than 75% of theoretical density are considered to be low density; those above 90% are high density; and those between these two ranges are considered as medium density. In general, structural and mechanical parts have densities ranging from 80% to above 95%. Many self-lubricating type bearings have densities of the order of 75%, and filter parts usually have densities of 50%.

Porosity — Quantitatively, porosity is the percentage of void volume in a part. A part which is 85% of theoretical density will have 15% porosity. Porosity in P/M parts can be present as a network of interconnected pores that extend to the surface like a sponge or as a number of closed holes within the part. Interconnected porosity is important to the performance of self-lubricating bearings and is part of the specification for these types of materials.

Porosity, which is a unique structural characteristic of P/M parts, is controllable and a function of the raw material and processing techniques. Parts can be produced either with uniform porosity or with variations in porosity (and density) from one section to another to provide different properties. For example, parts such as gears can be made self-lubricating in one area and dense and strong in other areas. The method for calculating pore volume or oil content of self-lubricating P/M components in terms of interconnected porosity is given in MPIF Standard 35.

Permeability — Permeability, or the ability to pass fluids or gas, is another unique property that can be designed into P/M products. Depending on forming and sintering techniques, a part can be made to have any permeability from zero to 60%. This property is important in filters. They can be produced with permeabilities that will separate materials selectively, diffuse the flow of gases or liquids, regulate flow or pressure drop in supply lines, or act as flame arrestors by cooling gases below combustion temperatures. Filters can be produced in almost any configuration including sheets and tubes.

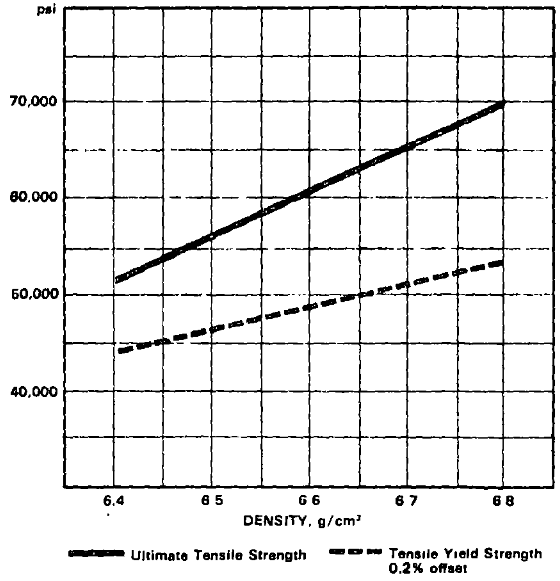
Mechanical Properties

As with wrought and cast metals, chemical composition strongly influences mechanical properties of P/M parts. However, in P/M parts there are the additional factors of density, pore size, shape and distribution, and extent of sintering, upon which the properties depend. Of these, density is most often used as a measure of P/M part properties.

For this reason, mechanical property data is commonly given in graphs showing the relationship between the property and density (or percent of theoretical density). The graphs or charts given in this publication represent typical values and the general trend of properties versus density that may be expected from test specimens conforming to the chemical and density requirements specified in MPIF Standard 35 (For more complete property data refer to Standard 35). It should be noted that test data obtained on standard specimens do not necessarily represent accurately the performance of the part itself, because variations in density in part and test specimen may not be comparable.

Figure 8

Strength vs Density (as-sintered)
P/M Copper Steel



Thus, test specimen data should be taken only as an approximation of evaluation of part performance.

Strength Properties—The accompanying graph, (Figure 8) shows ultimate tensile strengths and yield strengths of a representative pressed and sintered P/M material as a function of density. In general, yield strength is 65 to 85% of ultimate strength. Therefore, yield strength of P/M materials is generally closer to the tensile strength than in the case of wrought metals. Also, the yield strength of many P/M metals, particularly stainless steels, may be higher than that of the wrought form.

The relationship of fatigue strength to density is shown in Figure 9. It is evident that fatigue strength is best at high densities. For similar P/M and wrought compositions, the ultimate tensile strength to fatigue strength ratios are the same. However, fatigue strengths in P/M parts generally have greater stability and uniformity than wrought parts. Parts containing nickel show improved fatigue resistance compared to iron-carbon steels, and high density nickel steel parts can be case-hardened to improve wear and fatigue properties.

Figure 10 (a & b) gives impact strength value of a typical nickel steel part as a function of density.

Ductility—Ductility, which refers to the amount of plastic deformation prior to tensile fracture, is relatively low in P/M materials, chiefly due to the presence of pores. It is evident, then, that ductility is a function of density as illustrated in Figure 11. Measured in terms of percent elongation, values for ductility are generally less than 10% for ferrous P/M materials. However, elongations for some P/M brasses run up to 15 to 20%. Ductility of most P/M materials can be increased considerably by hot or cold repressing followed by additional sintering.

Hardness (Apparent)—Because of differences in structure, gross indentation hardness values of wrought metals and P/M parts can not be compared directly. A P/M part hardness value, when obtained using a standard tester and a standard scale, is referred to as "apparent hardness." It is a combination of powder particle hardness and porosity. (See MPIF Standard 43). This is evident from Figure 12, which shows how an indenter may penetrate the surface between particles or displace powder particles in low density parts. However, micro-hardness tests, such as Knoop or DPH if carefully done will measure true particle hardness.

Figure 9

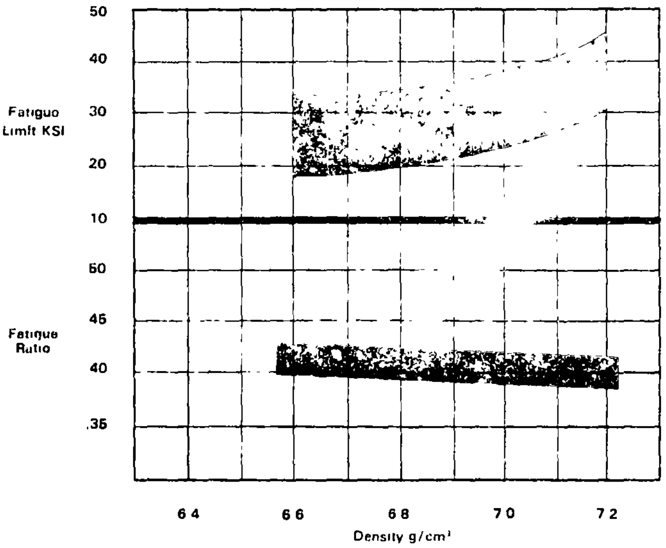
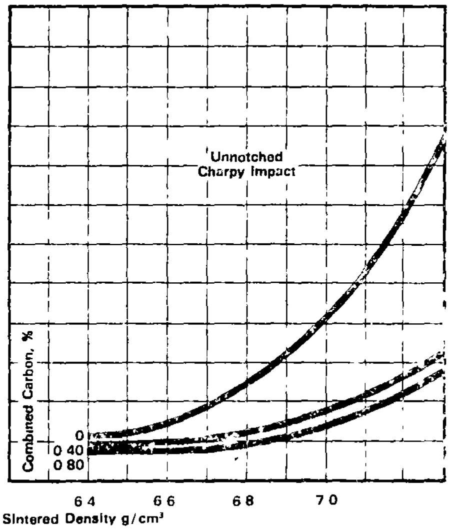
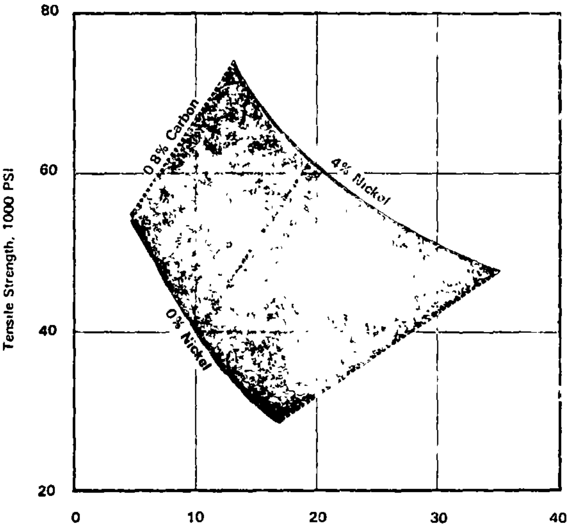


Figure 10 a



2% Nickel Steel

Figure 10 b



AS SINTERED STEELS WITH AND WITHOUT NICKEL
AT 7 0 g/cm³ DENSITY

Because of possible density variations, it is necessary to specify the area in which hardness measurements are made. Precautions must also be taken when interpreting surface hardness values on case hardened parts because the indentations sometimes break through the case (see MPIF Standard 37).

Corrosion Resistance

The presence of porosity in P/M parts is a significant factor affecting corrosion resistance. Entrapment of corrosive media is possible, causing internal corrosion. As with most other properties, corrosion resistance is improved by higher density. Stainless steel P/M parts have relatively good corrosion resistance in the atmosphere and in weak acids. Nonferrous P/M materials have corrosion resistant properties similar to those found in the wrought forms. For further information on corrosion resistance see the sections on heat treating and finishing.

Surface Finish

Excellent surface finish is an inherent feature of P/M parts. The overall smoothness and surface reflectivity depend upon density as well as tool finish, etc. Profilometer readings give an erroneous impression of surface smoothness (except at densities approaching 100%), because the instrument indicates total variation across a plane surface and does not recognize that the variations are practically all negative (i.e., below the smooth surface). When this is considered, surface smoothness of P/M ferrous parts compares favorably with ground or ground-and-polished steel surfaces. Surface smoothness can be further improved by secondary operations, such as repressing or honing.

Figure 11

Ductility As a Function of Density

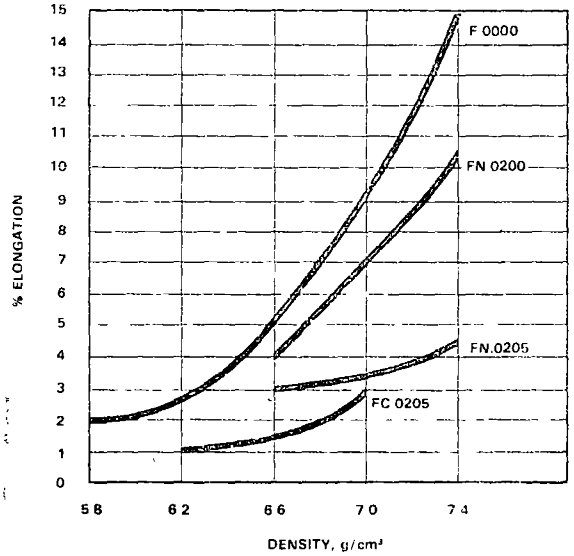
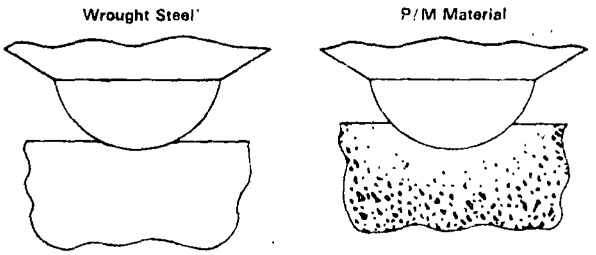


Figure 12



Sound Damping

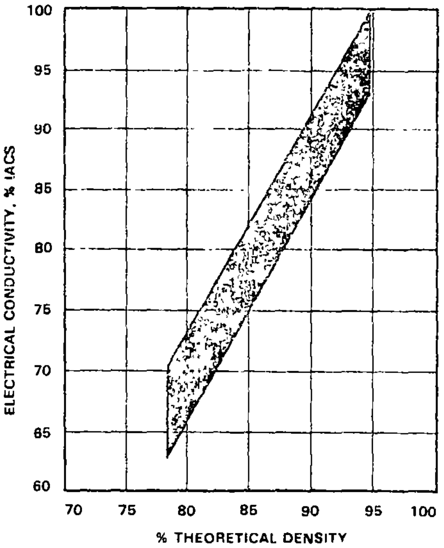
The porous nature of P/M parts provides good sound damping. Ringing, common with wrought steel gears and other parts, is reduced due to the controllable density in P/M products. This is an important benefit in dictating machines, business machines, air-conditioning blowers and similar products. The damping characteristics can be further improved by infiltration or impregnation with sound damping materials. P/M controlled density is also used for dissipating and muffling the sounds created by air driven power tools.

Physical Properties

Discussion of all the physical properties of P/M parts is beyond the scope of this publication. Suffice it to say that most physical properties, including thermal, electrical and magnetic properties, are closely related to part composition, density and porosity. Generally, at 100% density, property values would be comparable to those of the material in wrought form. Electrical conductivity, as shown in Figure 13, is a good illustration of this density-property relationship in P/M materials.

Figure 13

Electrical Conductivity of Copper P/M Parts



As with other parts fabricating methods, the P/M process has its own set of design capabilities and rules that must be considered to produce a soundly engineered product and to facilitate economical production. It is a common engineering axiom that a part should be designed always keeping in mind the method by which it is to be produced. By following this rule, design advantages are gained that are unique to the P/M process, and the limitations of the process are taken into account.

In order to design specifically for powder metallurgy, there must be close cooperation between parts user, or buyer, and parts producer, particularly in the initial stages of planning and design. Also, a P/M part should be designed in close conjunction with design of the whole assembly When possible, the parts manufacturer should have an opportunity to review part design in relation to the complete assembly before designs are frozen. Often through small changes in the assembly, a better and lower cost P/M part can be designed. And not infrequently such a systems approach will uncover opportunities for use of other P/M parts that will result in overall design simplification and cost reductions.

Tooling and Pressing Considerations

Closely related to P/M parts design is the tooling required to produce the part. Ideally, tool and part design should proceed together. Thus, by consultation between parts and tool designers, small changes in the part can be made to permit simpler tooling and facilitate production

Of the several steps involved in the P/M process, the compacting operation is the most critical and controlling one in part design. Therefore, as a general rule, the feasibility of making a part by powder metallurgy depends upon whether or not the desired shape, dimensions, detail and density can be obtained economically by pressing metal powder in the die.

There are two major factors in the compacting operation that control or influence part design. One of these is the flow behavior of metal powders. Because of friction between powder particles and between the particles and the dies and punches, metal powders do not flow hydraulically. Therefore, design must be such that the proper quantity of powder can be placed in the die close to its final mold location. This is particularly important in parts with thin walls and variable cross sections. Also, because metal powders have limited lateral flow, there are some limitations on contours that can be produced.

A second important consideration is the pressing action itself. Because compacting pressure is applied only from top and bottom, and not from the sides, this largely governs what shape and dimensional details and what length of part can be made with the desired density. Another consideration, also related to the pressing action is that part shape must allow the part to be ejected from the press.

We will now see how these factors affect specific aspects of the design of P/M parts.

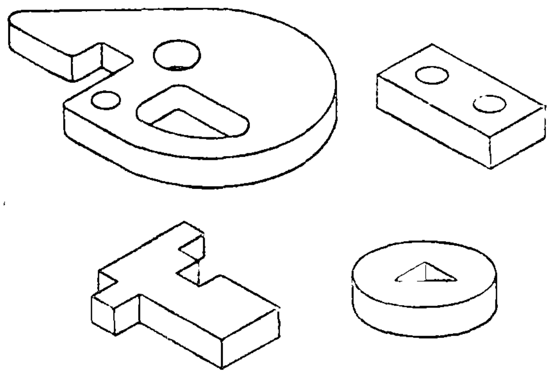
Sizes and Shapes

Part Size—Although there is no known theoretical limit to the size to which P/M parts can be pressed, maximum practical size is governed chiefly by available press equipment and powder characteristics. The majority of conventionally pressed P/M parts range in projected area from about 1/8 to 25 sq. in. (10 mm^2 to 0.015 m^2) and run between 1/32 and 6 in. (1 to 150 mm) in length. The maximum projected surface area possible depends on the material, part density and press capacity. Also, it is evident that for a given metal powder, the lower the density required, the larger the size of the part that can be produced on a given press.

A concern when designing parts that are relatively long in the direction of pressing is to obtain adequate density through the total length of the part, and particularly in the center section. Another factor limiting part length is the apparent density of metal powders. In general, compression ratio is at least 2 to 1. This means that the depth of the die must be more than two times the length of the pressed

Figure 14

Simple P/M Shapes



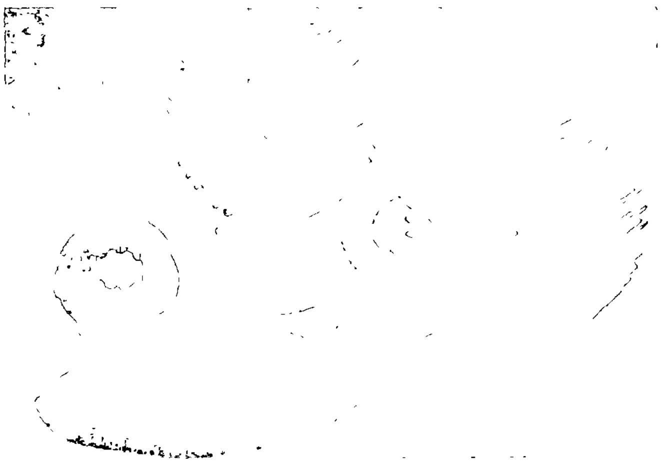


Figure 15

compact. Sometimes the thickness limitation is not a function of the press but of part design, such as where difficulty in filling thin wall sections (see below) may occur or core rod length may get beyond a practical limit.

Shapes—While a variety of shapes, sections and profiles can be produced by the P/M process, the most suitable ones are those that have uniform dimensions in the direction of pressing (Figure 14). These include simple cylindrical, square and rectangular shapes as well as odd shapes in which the contour is in a plane at right angles to the direction of pressing. For example, parts with radial projections and contours, like cams and gears and with no changes in thickness, are relatively simple to press.

Since the tooling is subject to enormous pressures, shapes that require fragile tools should be avoided. Also, the contour of parts must, under normal circumstances, allow ejection of the green compact from the die by means of an upward motion of the bottom punch.

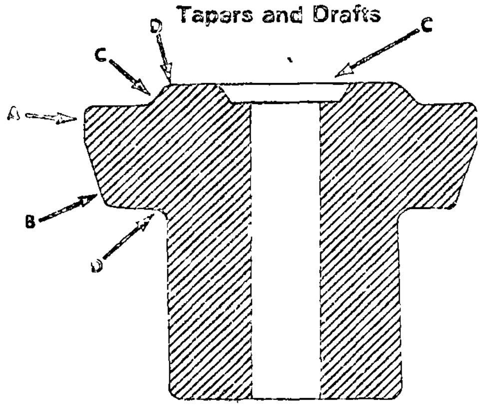
Because powders must be compressed and do not flow hydraulically, perfect spheres can not be made by the P/M process. Therefore, spherical P/M parts are designed with straight or flat areas around the equator. Parts that must fit into ball sockets are repressed to produce a more spherical shape. Hemispheres, such as those used in automotive ball joints can be readily compacted. Spherical depressions up to a hemisphere are also possible.

Multi-Level Shapes—As previously mentioned, P/M parts are pressed from the top and bottom and not from the sides (Figure 15). This, in addition to the fact that metal powders have almost no lateral flow, imposes certain conditions on a part having variations in thickness, such as steps, flanges, slots or grooves. Difference in thickness of up to 10 or 15% are feasible, if variations in density are acceptable. Variations of this magnitude can be formed in the punch faces.

When only limited nonuniformity in density can be tolerated or when the overall thickness variation is too great, multiple punch tooling or steps in the die or both, must be used to provide the needed variations in fill and compression. In many such cases, the part is held captive in the tools and special motions are required for proper ejection. Of course, multiple punches increase tool and equipment complexity and thus increase both original and maintenance costs. Therefore, when

Figure 16

Figure 17



design permits, keep the number of steps to a minimum and the thicknesses as uniform as possible.

Flatness — Flatness obtainable on a part is a function of a number of factors. Total measured flatness obviously depends on surface area. Also, it is affected by part thickness; usually thin parts tend to distort more than thick parts during sintering or heat treatment. Because of possible density variations in complex shapes and cross sections, flatness is more difficult to maintain than in parts of simple shape and cross section. Flatness can be improved in the case of soft metal parts by repressing, and in the case of hard materials by grinding. In some cases, small bosses or pads placed in critical areas minimize the total surface area that must be held "true."

Design Details

Holes — Holes in the direction of pressing are readily incorporated into P/M parts. They are produced by use of core rods that extend up through the tools. While round holes are least expensive, other shaped holes, including splines, keys, keyways, D-shapes, squares and hexagonals, can be produced at very little added tooling cost (Figure 16). Blind holes or blind steps in holes, and tapered holes which could be difficult to machine, are also readily produced. For tapered holes, a short length of the hole must be straight to accommodate the upper punch. Side holes, or holes not parallel to direction of pressing, cannot be made in the pressing operation and are generally produced by secondary machining.

Maximum diameter of holes possible in a part depends upon wall thickness (see below). Minimum diameter depends upon hole length. When length is too long relative to diameter, the core rod that forms the hole can bow during pressing and/or be pulled out during the ejection cycle. Also, thin pins are liable to breakage if the part is repressed due to large side or shearing forces.

Lightening holes are frequently used in large parts to reduce effective pressing area, with a reduction in weight and lower pressing force. In most cases, these advantages offset added tool cost, particularly if the holes are round.

Wall Thickness — Minimum wall thickness is governed by overall size and shape of the part. For parts of any appreciable length, walls should not be less than about 0.060 in. (1.6 mm) thick.

A wall less than 0.030 in. (0.8 mm) thick is generally considered too thin in all but tiny parts where thicknesses are also very small. Where the ratio of length-to-wall thickness is as high as 8 to 1 or more, special precautions must be taken to get a uniform fill, and variations in density are virtually unavoidable. With long, thin walls, it is also evident that the tooling required is quite fragile and has low life expectancy.

Tapers and Drafts — Draft is generally not required or desired on straight-through parts as is usually the case with die castings and other fabrication processes. While tapered side walls can be produced where required, production speed is slower in order to avoid powder being wedged between the taper of the die and other tool members during the fill operation. Tapered sections usually require a short, straight land to prevent the upper punch from running into the taper in the die wall or on the core rod (Figure 17a).

When a flange type section is made on a step in the die, a draft is desirable to assure proper part ejection (Figure 17b). Similarly, drafts on the sides of bosses or counterbores made by the punch face (Figure 17c) aid tool withdrawal and minimize possible chipping of the part.

Fillets and Radii — For most economical design of tools and production, generous radii fillets are desirable but not mandatory (Figure 18). Sharp edges or radii essential to a part's function should be specifically noted on the drawing. For noncritical corners or edges (Figure 17d), the part producer should be allowed as much flexibility as possible in order to use fillets or radii on edges most suitable for best tool construction and efficient part production.

A true radius is not possible at the juncture of a punch face and a die wall, since it would require that punch edge or skirt be feathered to zero; therefore, a full radius would have to be approximated by hand finishing or some other process such as tumbling (Figure 19).

Chamfers and Bevels — Chamfers, rather than radii, are preferred on part edges to prevent burring. For example, on rollers or bushings, such as shown in Figure 20, a 45 deg. angle and a 0.005 to 0.010 in. (0.13 to 0.25 mm) flat to eliminate feather edges is common. The preferred chamfer, and the one most economical to produce, is a maximum of

Figure 18

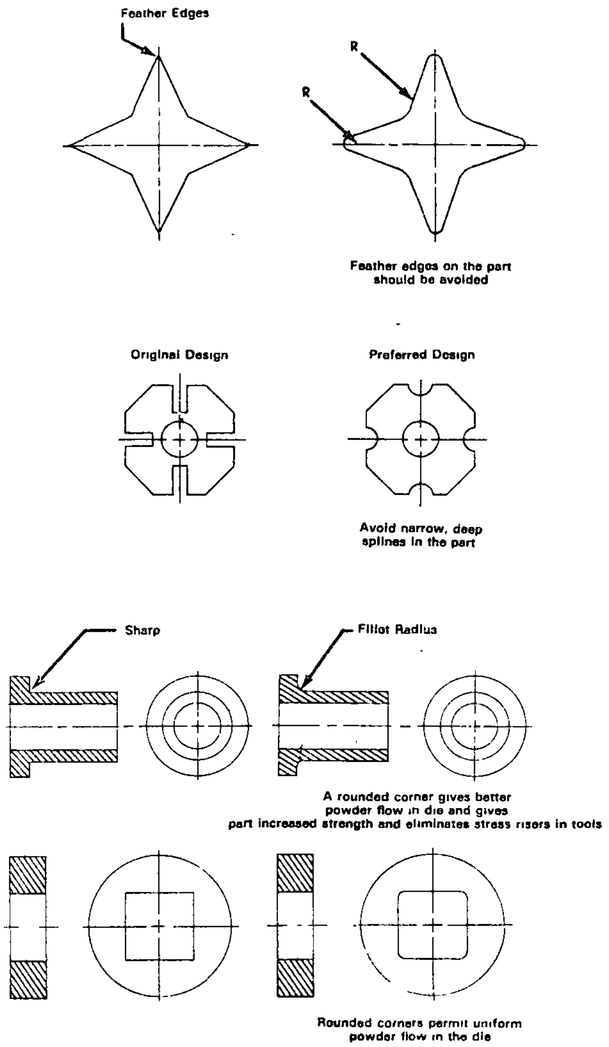


Figure 19

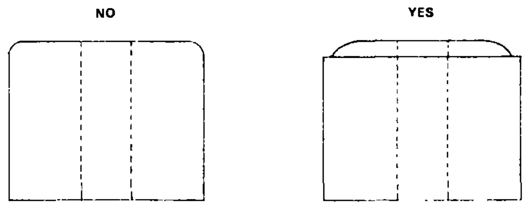


Figure 20

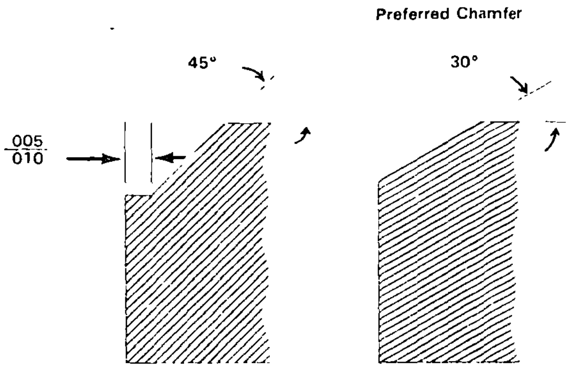
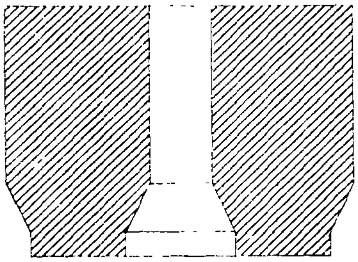


Figure 21



30 deg. to minimize chance of breaking the protrusion on the punch. Although flats are always desirable, their need is less critical as the angle of the chamfer decreases.

When chamfers with a large angle from horizontal are required for functioning of a part or when a step would create a problem (Figure 21), the chamfer may be produced by a bevel in the core rod or die. Under some circumstances, bevels as shown in the figure may make tool construction difficult and also decrease production rates due to fill problems and to wedging of powder between the tool members. In such cases, when repressing is part of the production cycle, it is often preferable to produce bevels in this operation.

The cost of chamfers can vary considerably depending on part shape and tool design. For example, a chamfer in a plain round part or on two sides of a square part costs relatively little, because the rim or skirt can be easily ground in the punch. On the other hand, irregular shapes, such as shown in Figure 22, require more work on the tooling, and therefore these chamfers are more costly to produce

Countersinks — A countersink is a chamfer around a hole for a screw or bolt head. A standard 82 deg. countersink, when produced by the punch, requires a skirt of 49 deg. from flat, which is larger than the recommended 30 deg. Therefore, a flat of about 0.01 in. (0.25 mm) is essential to avoid fragile, sharp edges on the punch. When this is done, theoretically a standard screw will not seat properly but rest on the edge of the step (Figure 23). If a P/M part is softer than the screw, the step usually will yield enough to allow proper seating. When a part is to be heat-treated or the screw will be subjected to high stress, it is advisable to machine out the step or to decrease the angle enough from standard to allow the step edge to be cleared. The 82 deg. angle may also be put on a core rod in some cases.

Flanges — A small flange, step, or overhang can be produced by a shelf or step in the die. Beyond a certain point, when the amount of overhang becomes too great to permit ejection without breaking the flange, additional punches and other tooling techniques are required. If the stepped die method is used, some draft around the flange edge is usually needed, as well as a radius around the bottom edge and at the juncture of the flange and body of the part (see Figure 17).

Bosses — A boss can generally be located on top or bottom of a part under the following conditions: 1) Height must be small compared to the overall part thickness — preferably 15% or less. 2) A round shape is preferable. Other shapes may require relatively costly tool manufacturing methods, such as EDM or an engraving technique to produce the depression in the punch. 3) Draft angle should be as broad as possible (at least 45 deg.) to avoid locking of the boss in the punch surface. To produce bosses with perpendicular sides, special punch members are required to give positive part ejection.

Hubs — Hubs, which provide for drive or alignment ridgidity in gears, sprockets and cams, can be readily produced by the P/M process. A variety of shaped holes in the longitudinal direction are possible. Setscrew holes at right angles to the drive axis are produced by secondary operations. When designing hubs, include a generous radius between the hub and flange, and allow maximum permissible space between the hub OD and root diameter of such parts as gears and sprockets. Hubs that serve also as self-lubricating bearing surfaces can be produced at lower density than other portions of the part so that they will have high oil capacity. Relatively shallow hubs can be treated as bosses (see Bosses).

Studs — Shallow studs with drafted sides are made simply in the regular tools (see Bosses). Where no draft is allowed or where height-to-diameter ratio is relatively large, particularly with respect to the overall shape of the part, additional tool members are required for proper compaction and ejection (see Hubs). In general, avoid a small diameter hub or protrusion on a comparatively large and heavy part, because of its fragility in the unsintered state. An alternative is to provide a hole in the part into which a pin can be assembled as a secondary operation.

Knurls — Straight, but not diamond, knurls can be made on outside diameters. Ground diamond knurls in the punch face reproduce as a waffle structure on the part (the reverse of a true diamond knurl). To reproduce a true diamond knurl on the part, the punch must be engraved or finished by the EDM process.

Figure 22

Chamfer on an Irregular Shape

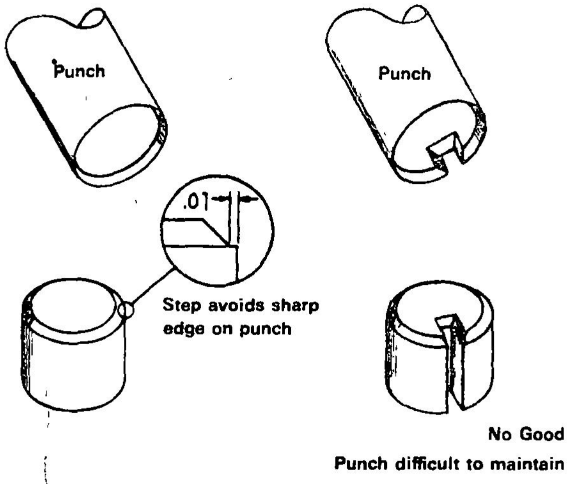


Figure 23

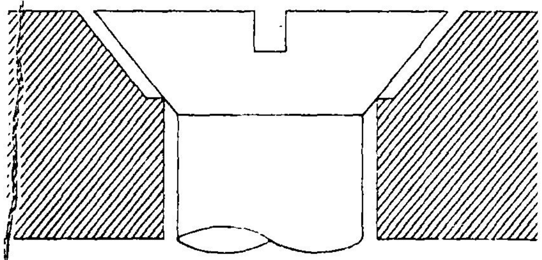
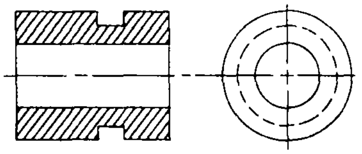
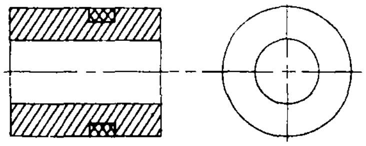


Figure 24

Original Design



Preferred Design



Undercuts cannot be molded
They can be machined

Figure 25

Cannot Do

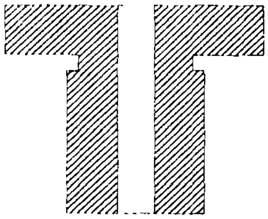
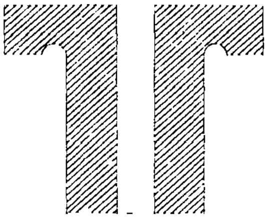


Figure 26

Preferred



Undercuts — Undercuts on the horizontal plane (perpendicular to the die center line) cannot be produced if they prevent the part from ejecting from the die. Annular grooves around a part, as shown in Figure 24, are produced by machining or by making the part as an assembly of two pieces (see Assemblies). On a part, such as shown in Figure 25, where an undercut in the flange is needed to allow fit-up to a dead corner, an alternative approach is shown in Figure 26. A part with a reverse taper (larger on bottom than on top) cannot be ejected from the die.

Threads — Because threads in holes and on outside diameters prevent a part from being ejected from the die, they cannot be made by conventional P/M methods, but can be produced by secondary machining operations.

Tolerances

The tolerances that can be held in the P/M process compare favorably with those of many of the other conventional parts fabricating processes. In most cases they can be held closer than in parts made by sand casting, die casting, stamping and forging. Of course, as is true for other processes, tolerances no closer than necessary should be specified whenever possible, for the closer the tolerance requirements the higher the cost of production.

Tolerances on P/M parts depend upon the following factors:

1. *The metal powder.* Materials differ in how much they are affected by variations in sintering time, temperature and atmosphere, as well as by variations in density.
2. *Size of dimension.* Because dimensional stability is a proportional change, a large dimension will have greater variation than a small dimension.
3. *Tool wear.* Tool wear is usually affected by the material and its density, by the tool material, and by the number of parts produced. As tools wear, a part's outside dimensions become larger and inside dimensions become smaller
4. *Run-out tolerance.* The run-out tolerance on parts with a hole, such as in gears, is affected not only by die accuracy but by the required running clearances between moving members of the tools. On flat, round parts with a concentric hole, a run-out of 0.001 in. (0.03 mm) can be expected before any other factors, such as tool wear or sintering size

changes, are taken into consideration. On parts with hubs or multiple hubs for which a number of concentric tool members are used, the initial run-out tolerance can be larger. The same considerations hold for hole-to-hole tolerance because of the need for running clearance of the tools

5. *Heat treatment.* As with wrought materials, heat treatment of P/M parts can cause dimensional changes. Size changes tend to be larger in low density parts because the heat treating atmosphere penetrates deeply and quickly.

6. *Coining and repressing.* Closest tolerances are obtained by coining or repressing parts. Sizing does not necessarily block the pores in medium density and low density parts that are to be self-lubricating. Of course, an increase in density does reduce the oil holding capacity.

Design of Typical Parts

Gears and Ratchets—The P/M process is particularly well-suited to the production of gears for several reasons: 1) Using carbide dies, good part-to-part consistency is obtained, because form accuracy is maintained over long runs. 2) Retention of some porosity is conducive to quiet running gears and allows for self-lubrication. 3) P/M gears can be made with blind corners (Figure 27), thus eliminating undercut relief that is needed with cut gears and have extra support strength at the blind end. 4) P/M gears can be combined with other parts such as cams, ratchets, other gears, and assorted components. 5) Bevel, miter, helical and other special gear forms are possible Copper infiltration is sometimes used on bevel or miter gears to improve density in the entire tooth 6) True involute gears are less difficult and less costly to produce than by other methods because tooth configuration is not a limitation of P/M.

Here are a few specific gear design aids:

1) Location of the hole relative to the gear form is affected by running clearances of the various tool members. Therefore, it is more difficult to hold the close TIRs obtainable with arbor cut gears. 2) Hubs or pinions that increase the number of concentric

Figure 27

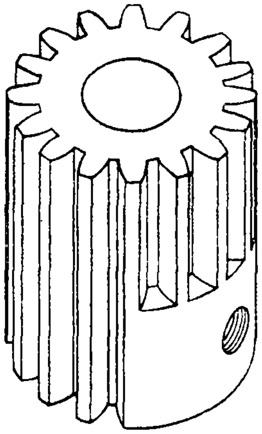


Figure 28

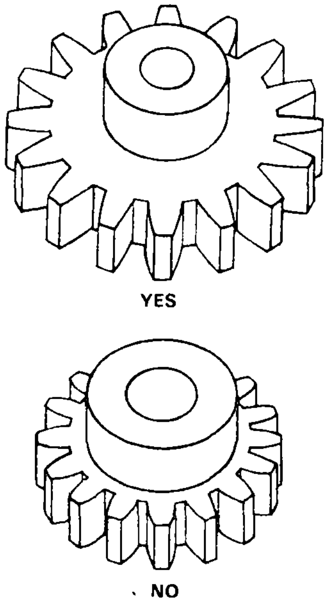
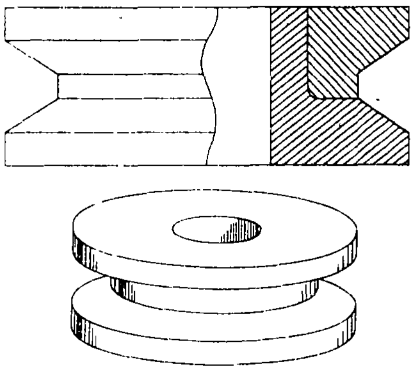


Figure 29



tool members, increase the needed TIR tolerance and should be located as far as possible from the gear's root diameter to avoid thin tool sections (Figure 28). Where this is a problem, two-piece assemblies should be considered. 3) As the class of gear increases, the cost of a P/M gear increases because of additional operations, such as sizing or repressing, boring, honing and grinding.

Ratchets, like gears, are readily produced by the P/M process. Where possible, undercut teeth should be avoided and maximum possible radii allowed at the tip and at the root.

Cams—Cams use many of the unusual design attributes of the P/M process, such as excellent surface finish, high part-to-part form consistency and self-lubrication. The natural finish of a self-lubricated P/M cam will often outwear a ground cam surface.

For radial cams, the cam shape is formed in the die. For "face" cams, the shape is formed in the punch faces or as steps in the die. Both radial and face shapes can be made in one P/M cam. Also, cams can be produced in combination with gears, ratchets, valve port openings, etc.

Assemblies—Two or more P/M parts can often be joined together to form a unit that is difficult, if not impossible, to make as a single structure. Several parts can be joined together to form simple undercuts, to eliminate machining operations, or to form something like a V-type pulley as shown in Figure 29. Two piece assemblies, although not impossible as one piece, may be more practical to make as an assembly of several comparatively simple parts and thus avoid costly tooling. Also, an assembly can sometimes take advantage of the different properties of various P/M materials, such as a bronze bearing in a ferrous structural part and a heat-treated part with a non-heat-treated part.

P/M parts can be joined together by conventional methods, such as staking, pressfitting, and other methods of upsetting, as well as by brazing, soldering, welding, cementing, riveting and bolting. Where different materials are involved, parts can be joined together during the sintering operation by taking advantage of differing size change

Table I
Permissible Loads for Standard P/M Bearings

Shaft Velocity, ft. per min.	Permissible Loads, psi				
	BT-0010-N	BT-0010-R	BT-0010-S	F-0000-N	FC-1000-N
Static	5,500 max	8,500 max	11,250 max	7,500 max	15,000 max
Slow and intermittent	3,200	4,000	4,500	3,600	8,000
25	2,000	2,000	1,800	1,800	3,000
50 to 100	550	500	450	400	700
100 to 150	365	325	300	235	400
150 to 200	280	250	225	175	300
Over 200	$P=\frac{55{,}000}{V}$[1]	$P=\frac{50{,}000}{V}$	$P=\frac{45{,}000}{V}$	$P=\frac{35{,}000}{V}$	$P=\frac{40{,}000}{V}$

[1] For shaft velocities of 500 to 1000 ft. per min. $P=\frac{60{,}000}{V}$ (for BT-0010-N)

Where

P = safe load in pounds per square inch of projected bearing area (length times inside diameter of bearing), and

V = shaft velocity in ft. per min.

characteristics. For example, outside parts can be designed to shrink during sintering relative to the inside part to produce a strong bond between the parts. Although this method may not cause the interface to disappear and form a 100% complete bond, the joint strength may be sufficient for many applications. Higher strength can sometimes be gained by locking interfaces or by infiltration, which can increase the strength of the bond as well as of the part itself. If the parts are "over infiltrated" the results may be like those obtained in furnace brazing but at the expense of some dimensional accuracy.

Bearings — Because of the unique property of controlled porosity possible with the P/M process, bearings are a natural P/M product. Furthermore, by design, P/M parts can be made with bearing surfaces to a desired degree of porosity for self-lubrication while working surfaces can be designed to higher density for higher strength or hardness. This design flexibility can save costs by eliminating need for a separate bushing and its assembly with the working part.

Plain bearings, flanged bearings, spherical bearings and thrust washers are commonly produced. Table 1 gives permissible loads for various standard P/M bearings. When designing for P/M bearing loads, operating and housing conditions should be considered. External lubrication, cooling and hardened or chromium plated shaft surfaces tend to increase the permissible loads. Repeated start-stop operation, oscillatory or reciprocating motion, high speeds, shock load and temperature extremes tend to decrease permissible loads.

For detailed information on tolerances, types of oils, impregnation, etc. see MPIF Standard 35.

If you are responsible for purchasing or specifying components, powder metallurgy can provide excellent opportunities for cost reduction while maintaining or improving quality. This section of the Guidebook is intended to help you get the most out of evaluating and purchasing P/M products.

The importance of discussing the part and its application with an experienced and a competent P/M manufacturer cannot be overstressed. It's the only sure way to take advantage of the best techniques in a rapidly changing industry. When requesting a quotation, furnishing accurate and complete information will result in the lowest cost for acceptable parts. In addition to a part drawing, the following information should be provided:

1. Order quantities and annual usage.
2. Mechanical properties (tensile strength, elongation, hardness).
3 Unusual service conditions (heat, impact, moisture).
4. Finish (plating, oxide coating, surface roughness).
5. Is the part to be furnished complete to print or must secondary operations be performed, and by whom?
6. Can the design be modified? If so, where?
7 Describe the application. Assembly drawings and samples of existing parts can be helpful.
8 For bearings, shaft material, finish, speed and diameter should be noted.
9. For gears, splines, sprockets, etc. specific data is required: 1) number of teeth, 2) Theoretical pitch diameter, 3) Pressure angle, 4) Measurement over wires, 5) Tooth thickness, 6) Backlash, 7) Helix angle, 8) AGMA quality class.
10. Refer to industry materials standards and specifications (MPIF Standard 35).

In general, it's important to describe what is required, not how a parts manufacturer must make it. Differences in manufacturers' techniques and equipment may result in several processing methods which can all produce satisfactory parts. Manufacturers' capabilities and specific cost elements will result in limited cost variations among competitive bids, but gross differences in prices may indicate a serious misunderstanding of requirements.

The powder metallurgy process allows considerable cost variation if specific part requirements are not clear. Reasons for widely differing costs may be determined by asking questions like these: 1) Are tolerances revised on quotations? 2) Are one supplier's manufacturing practices very different from another? 3) Is one repressing and another supplying a single pressed part? 4) Has a minimum density been specified?

If P/M is new to you, there can be a reluctance to commit several thousand dollars in tooling without sample parts. Unfortunately, there is no low-cost "temporary" tooling in P/M as in some metal working processes. This is another good reason to be specific about part requirements so that you and your supplier are both confident of success. For assurance you may want to machine prototype parts from the exact material specified. Most P/M manufacturers will provide sample material at a reasonable cost. Experience has proven this method very reliable but only if the P/M manufacturer has had the opportunity to relate the sample to a part design and performance requirements.

Customers interested in reducing costs of existing parts frequently ask that the current material used be matched in properties with the P/M part. While most properties can usually be met, identical properties across-the-board are often impossible and not always necessary. Again, the need for specifying the required properties is apparent.

Be sure your supplier has adequate quality control methods. P/M processing has many variables that must be monitored to guarantee consistent results. Routine QC procedures must be in use to assure material composition, correct density, and adequate sintering. Also, suppliers and buyers often establish test procedures to be used for acceptance.

P/M parts producers are anxious to educate current or potential customers. For further technical information and a list of publications, and materials and testing standards contact the Metal Powder Industries Federation, P.O. Box 2054, Princeton, New Jersey 08540; (609) 799-3300. For a directory of custom fabricators of P/M parts and products contact the Powder Metallurgy Parts Association at the same address.

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Sponge iron powders
Höganäs AB

Materials y procesos de fabricación
E. Paul DeGarmo
Editorial reverté Argentina S.R.L.

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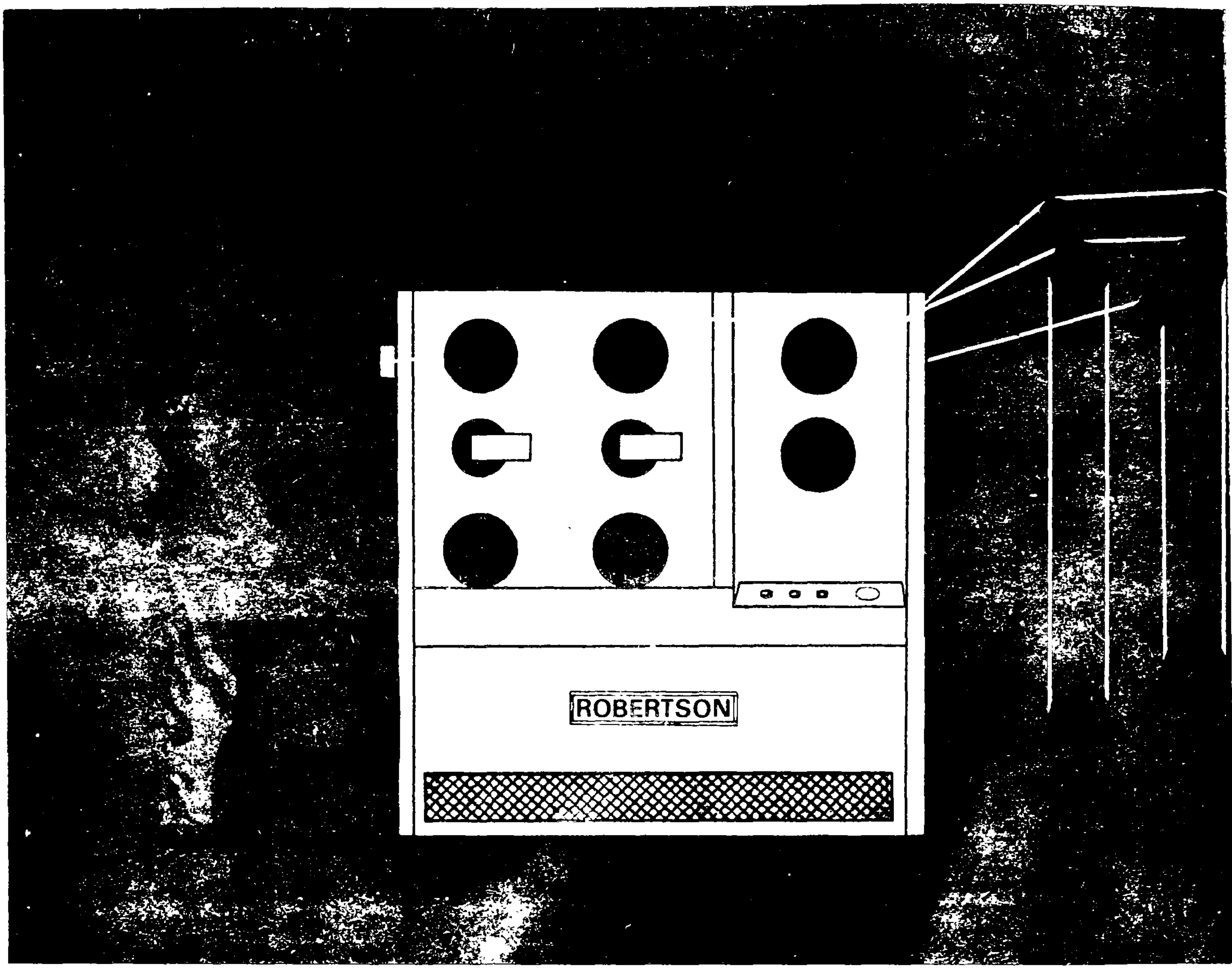
DISEÑO DE HERRAMENTAL

ESTIRADO

ING. ULRICH SCHARER SAUBERLI

JUNIO, 1978.



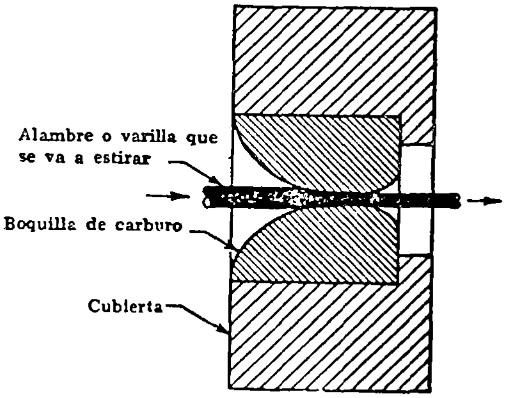
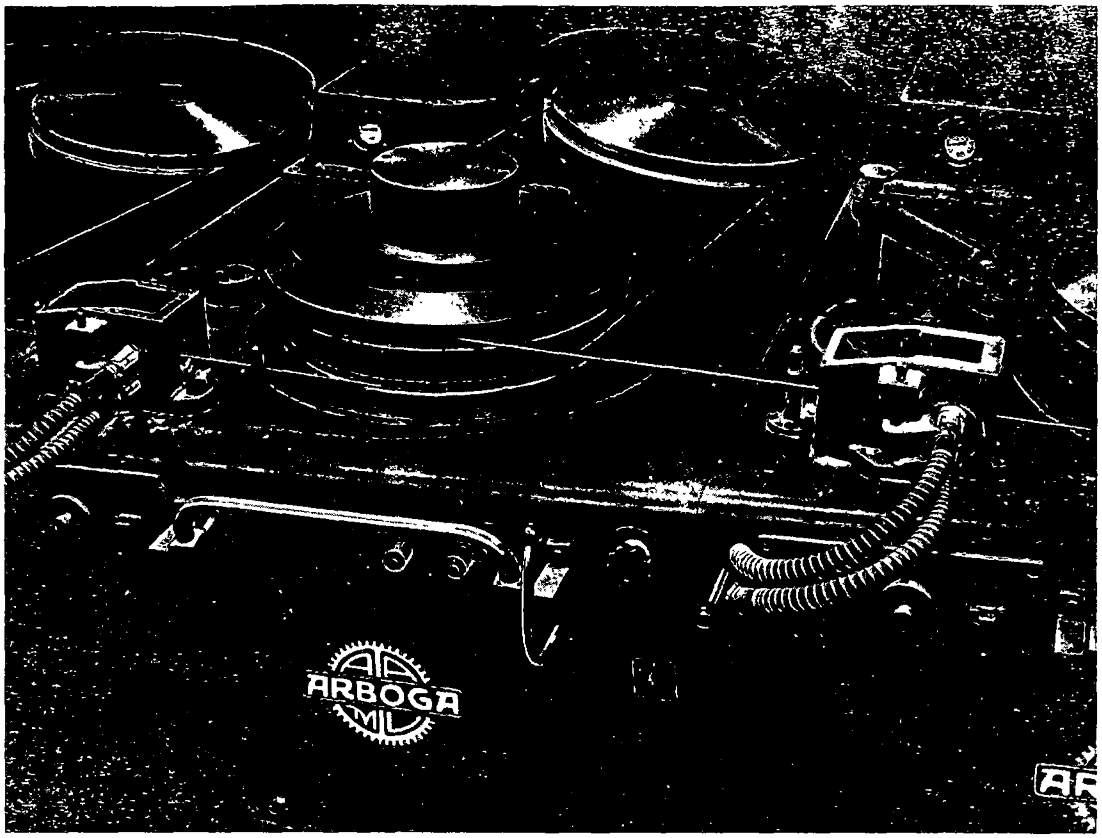


FIG. 2. Corte a través de una matriz para estirar alambre



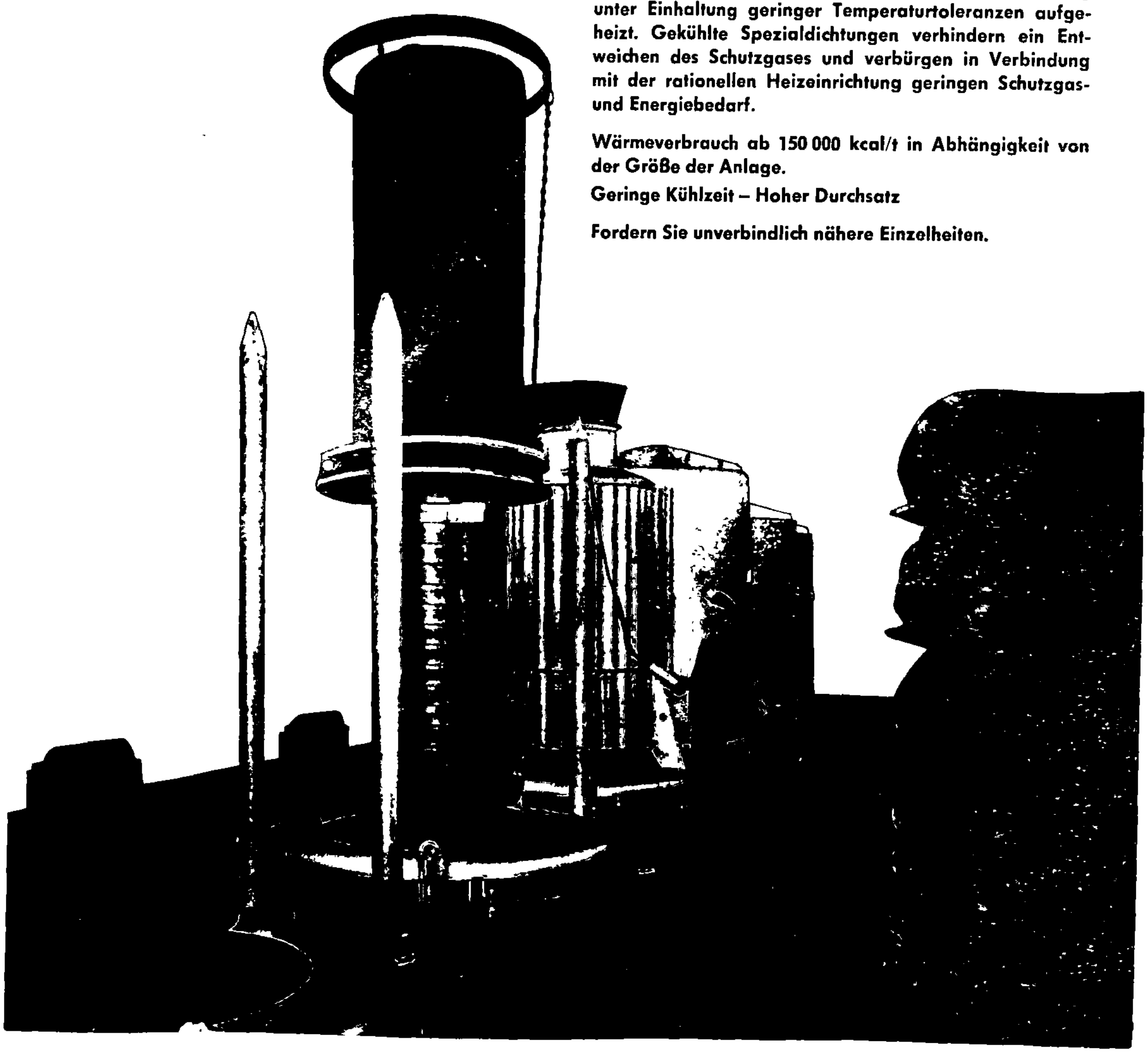
Drahtziehmaschine typ Loopline L3B Spezial mit Schlingenregelung. Separate Gleichstrommotoren und Thyristorengleichrichter für jeden Block. Sonderausführung mit großen Umlenkrollen für das Ziehen von Rohrdraht für Automatenschweißung.

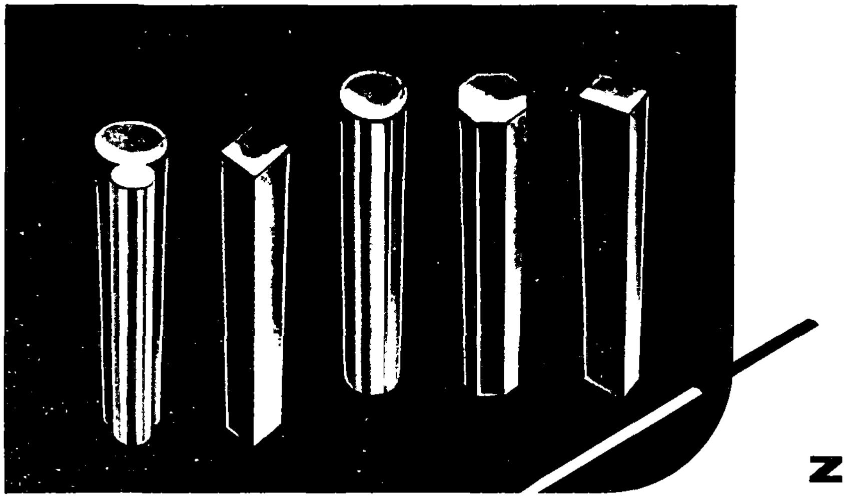
Durch intensives Umwirbeln des Schutzgases in der Glühhaube wird die Charge in kurzer Zeit sehr gleichmäßig unter Einhaltung geringer Temperaturtoleranzen aufgeheizt. Gekühlte Spezialdichtungen verhindern ein Entweichen des Schutzgases und verbürgen in Verbindung mit der rationellen Heizeinrichtung geringen Schutzgas- und Energiebedarf.

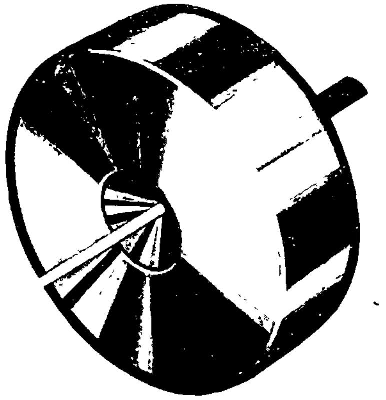
Wärmeverbrauch ab 150 000 kcal/t in Abhängigkeit von der Größe der Anlage.

Geringe Kühlzeit – Hoher Durchsatz

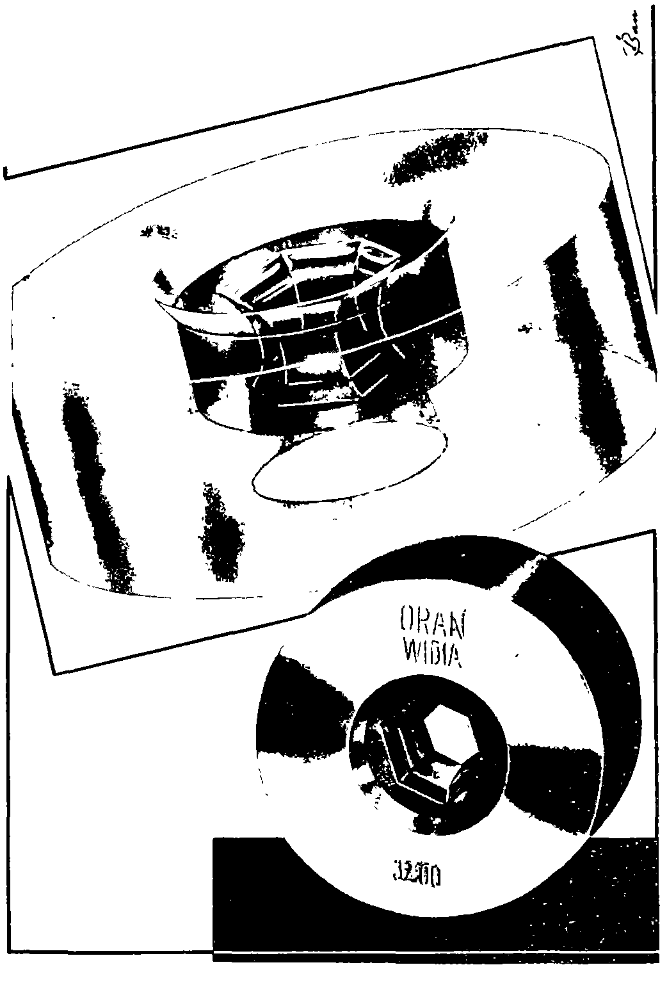
Fordern Sie unverbindlich nähere Einzelheiten.

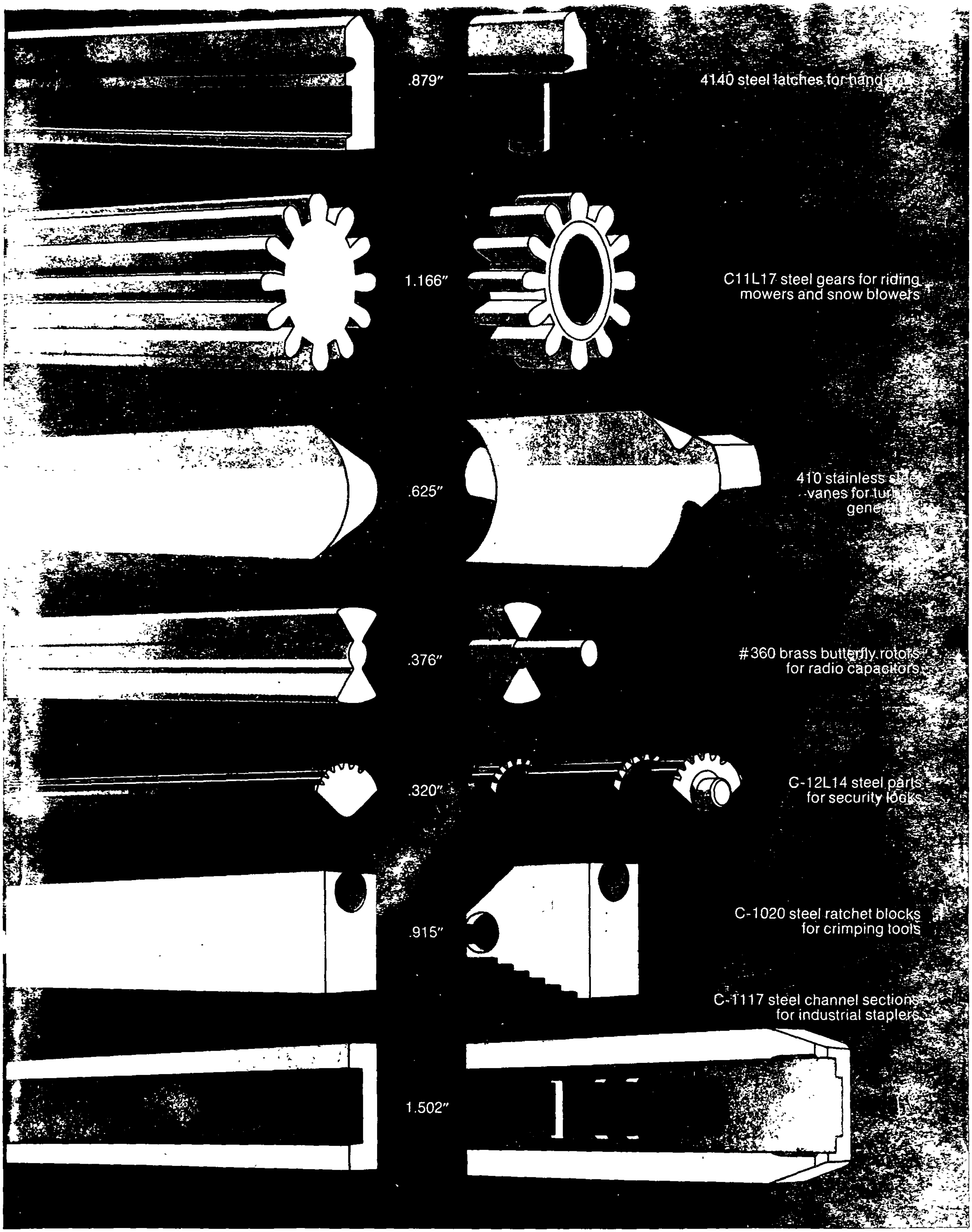






ZIEHWERKZEUGE




.879″
4140 steel latches for hand guns
1.166″
C11L17 steel gears for riding
mowers and snow blowers
.625″
410 stainless steel
vanes for turbine
generators
.376″
#360 brass butterfly rotors
for radio capacitors
.320″
C-12L14 steel parts
for security locks
.915″
C-1020 steel ratchet blocks
for crimping tools
C-1117 steel channel sections
for industrial staplers
1.502″

Rathbone precision cold drawn shapes speed-up small part production, reduce metal scrap loss, cut your costs!

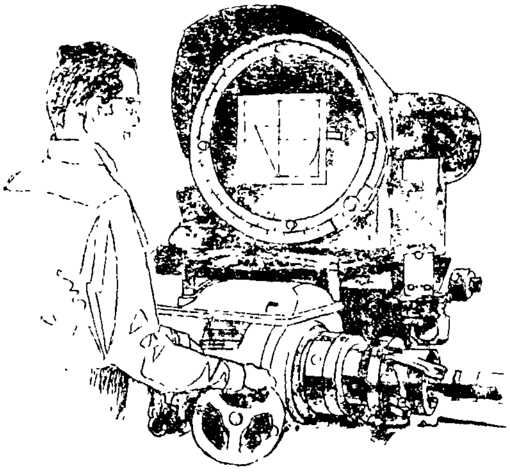
Slice a piece from a cold drawn bar, accurately shaped to your specifications, and your small part, gear or ratchet is practically finished. Most of the machining operations have been eliminated—along with the loss of metal you would have machined away.

- In cold drawing, coiled wire and bars are pulled through dies and the metal displaced is added to the length of the stock. You use almost every pound of material purchased.
- Rathbone profile shapes and pinion rods are free from variations in sectional dimensions along their entire lengths. Standard tolerance is ±.002″—even closer where required. Each part cut from the drawn rod is an exact duplicate. Accurate point location for final processing is assured.
- Finishing time is reduced because cold drawing imparts a smooth, burnished surface to the shape or gear and tolerances are close. Secondary finishing operations are often eliminated. And cold drawing forces imperfections to the surface where they can be easily seen and eliminated before shipment. This reduces your pre-machining inspection time.
- Assembly costs are frequently eliminated. Cold drawing often makes it possible to combine two or more components in a single shape. Intricate shapes, such as dovetails and other re-entrants, asymmetricals and undercuts, which are impossible or expensive to produce by extruding, machining or rolling, present no problems.
- Cold drawing increases tensile and yield strength. Smaller cross sections can be used without sacrificing strength or wear resistance, designs can be more compact and material costs can be lowered.
- Replacement costs are minimized. The increased strength, improved grain structure and hard skin of the cold worked surface mean longer part life at peak performance. Close tolerances assure you that each part will do the job for which it was designed.
- And you have a wider selection of materials Stainless, alloy, high and low carbon steels; brass; bronzes, coppers—any metal that can be cold worked—with no compromise to meet particular machining methods.

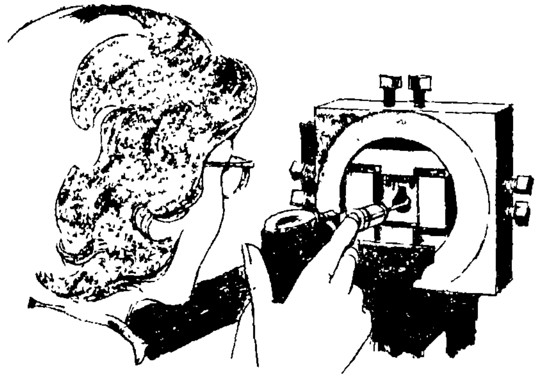
Rathbone precision cold drawn shapes extend your design and production capabilities!

Here's how The Rathbone Process does it.


Production engineering


Roll machining


Die making and polishing



Rathbone was the first company in America to manufacture cold drawn shapes. The quality and precision of its products are a result of three generations of specialization. Close to 300 of *Fortune* magazine's list of 500 largest corporations have used Rathbone profile shapes or pinion rods

The Rathbone process is a combination of precision die making, [illegible]rt cold drawing and careful annealing

The basic contour of a symmetrical or irregular profile shape is established by cold rolling. Cold rolling passes are usually preceded by annealing. The shape is then refined and reduced to extremely close tolerances by cold drawing. Each cold drawing pass, where the rod is pulled through a tungsten carbide or steel die, requires pointing of the bar and is almost always preceded by annealing. Some shapes require as many as 20 rolling and drawing operations. Finally, shaped rods are shipped in coils or in mill length rods straightened to a maximum of .010″ bow per foot, less if required.

In the production of pinion rods, round bars are longitudinally shaped in a series of cold drawing and annealing steps to precise cross sections. Most pinion rods are furnished in as-drawn temper in coils or in straight 12′ lengths for feeding into automatic screw machines where they are cut and finished into gears. Similar to pinion rods are spline, knurled and ratchet rods.

Drawing the metal through the dies substantially increases strength and toughness. And since it is worked cold, the improved qualities are uniform the length of the bar and the cross section is accurately controlled.

In contrast, the extrusion process, though often cheaper, introduces heat. As the temperature varies, the opening through which the metal is rammed expands and contracts affecting the size and shape of the cross section. Temperature changes also produce an inconsistent granular structure. Because of the heat induced plasticity, surface hardness is lower and it is extremely difficult to extrude shapes with sharp corner undercuts.

Machining the part, in addition to being much more expensive, cuts away the original cold worked skin reducing surface hardness and wear resistance and increasing surface drag Cold drawing preserves the hard surface in the finished shape.

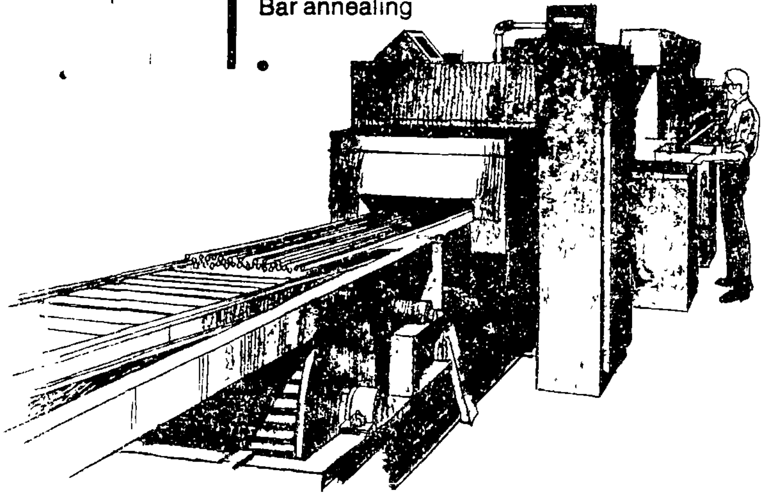
Cold rolling alone cannot produce complex shapes nor meet tight tolerance specifications and long runs are necessary to amortize the cost of setting up the rolling mill.

The major advantages of cold drawing over other methods are (1) unmatched precision the length of the bar, (2) ability to produce complicated shapes, (3) uniform strength and toughness, (4) almost no material waste, (5) economy, even in relatively short runs, (6) less finish machining, (7) improved part performance, and (8) a wider range of materials from which to choose.

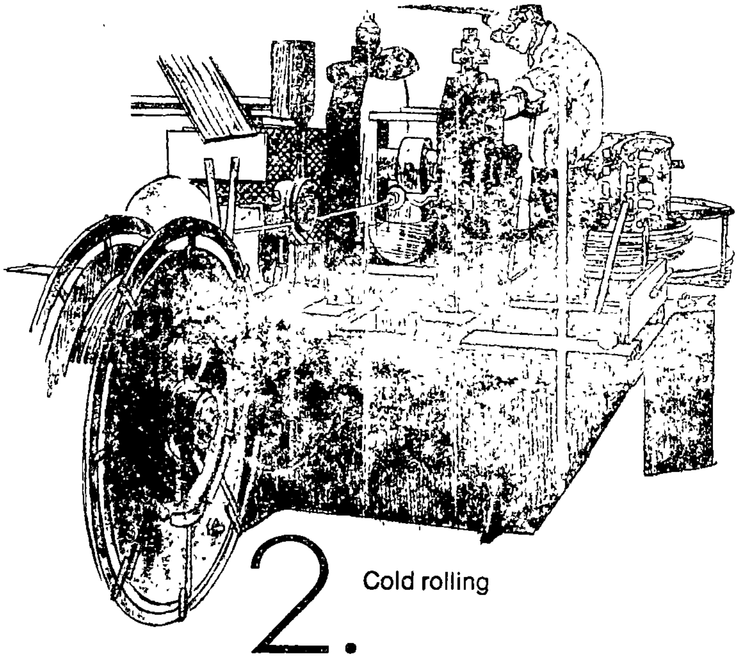
While some metals lend themselves to cold drawing better than others, the Rathbone Process can shape any material that can be cold worked This includes:

Stainless steels
Alloy steels
High and low carbon steels
Nickel and nickel alloys
Brass
Bronzes and nickel silver
Copper and copper alloys,
  including Beryllium copper

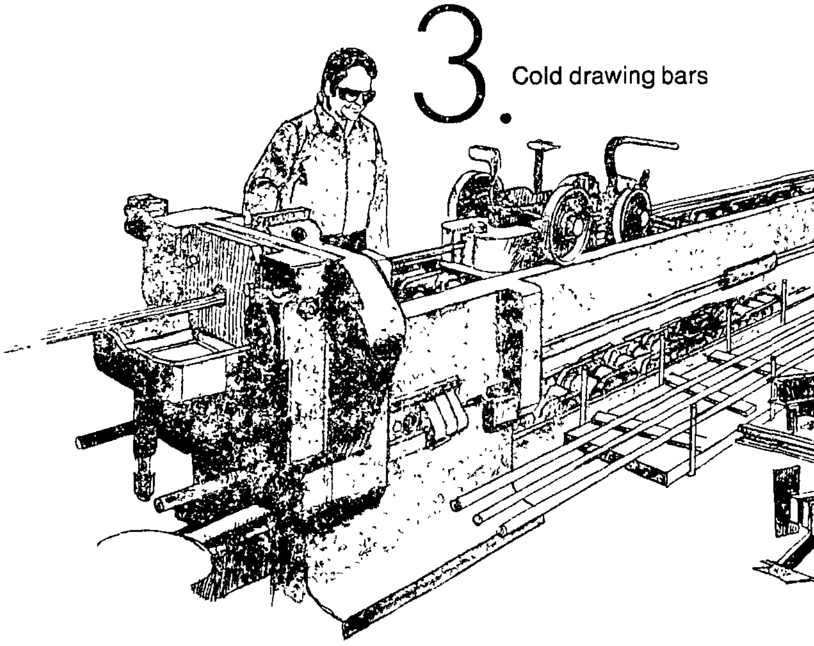
Material should be chosen carefully Dimensional accuracy is affected by the plastic flow. A metal that lacks ductility and has poor drawing qualities cannot be held to as close a tolerance as one with good cold working properties. In spite of the difference in raw material costs, sh[illegible]s made of easily drawn metals can usually be produced at a lower cost. It is therefore important to contact Rathbone early in the design stage in order to save as much money and production time as possible



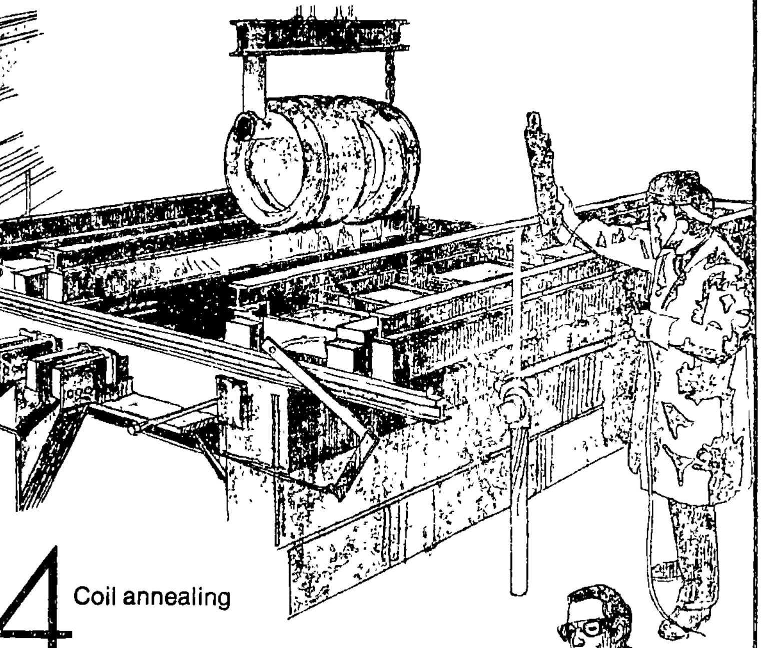
1. Bar annealing



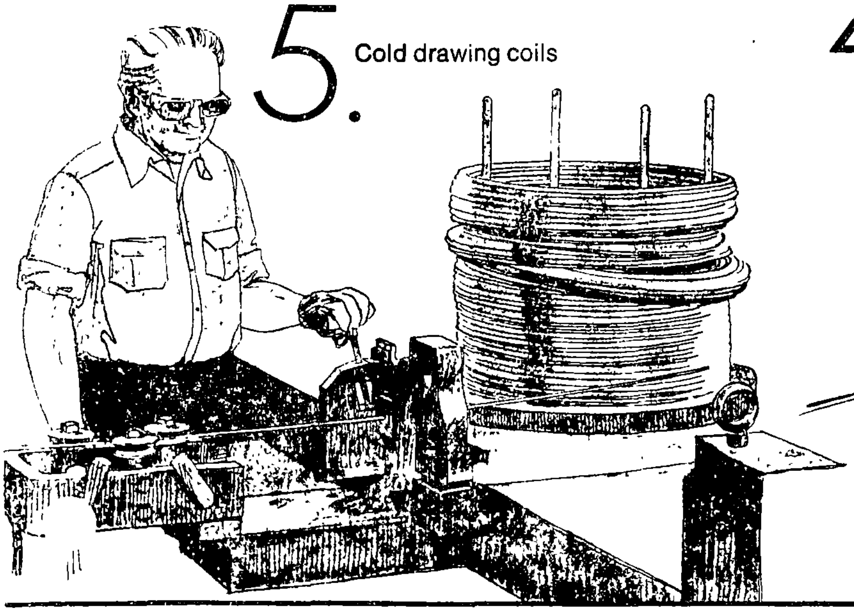
2. Cold rolling



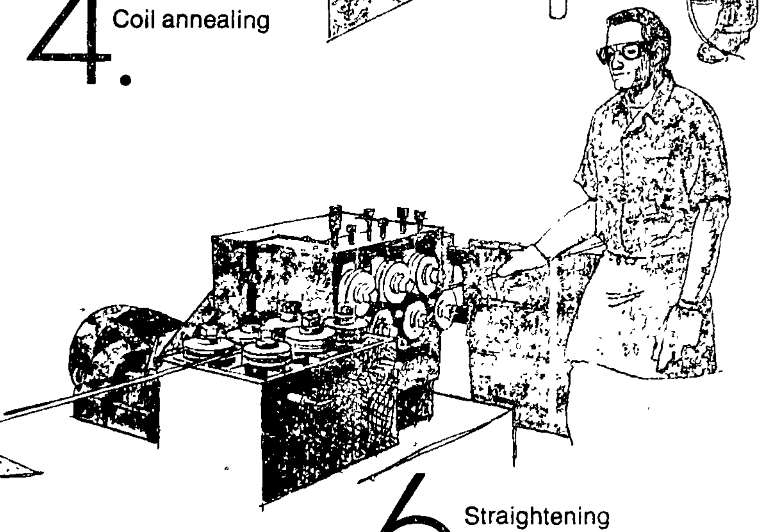
3. Cold drawing bars



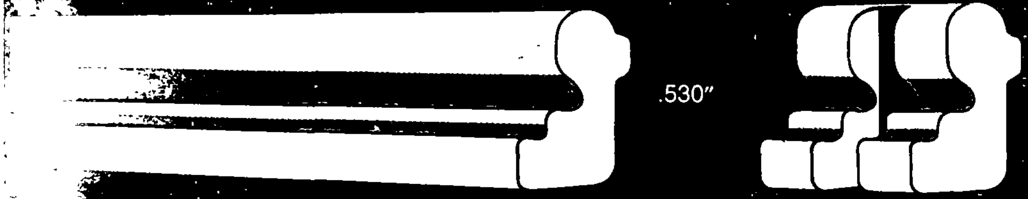
4. Coil annealing



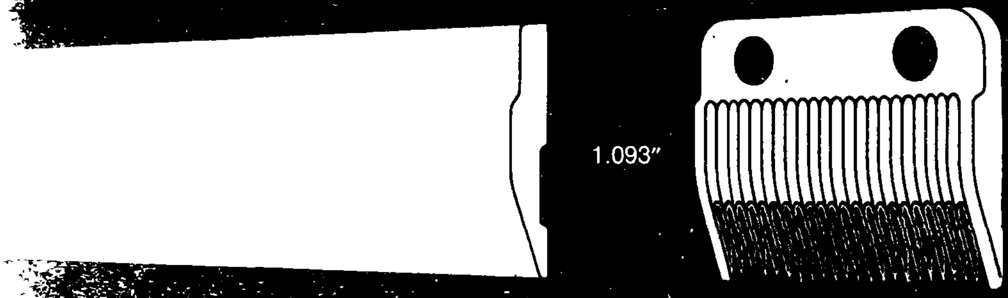
5. Cold drawing coils



6. Straightening

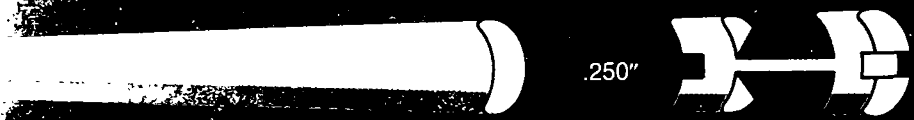


#360 bras

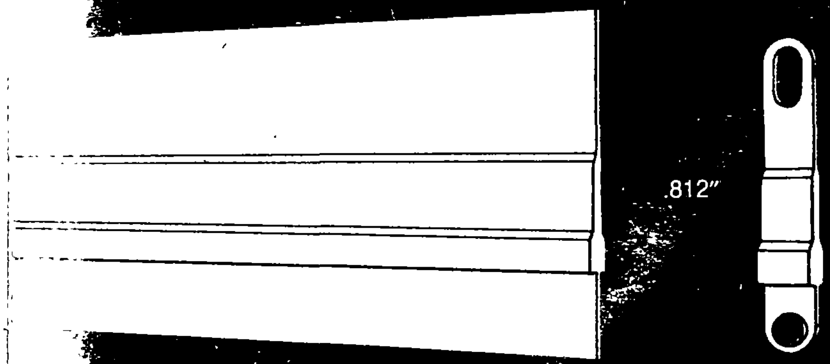


.95/1.10% high ca
hair clippe

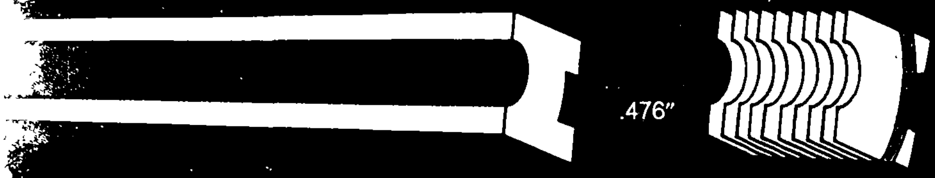
C-12L14 steel typewrit



303 stainless steel belt co

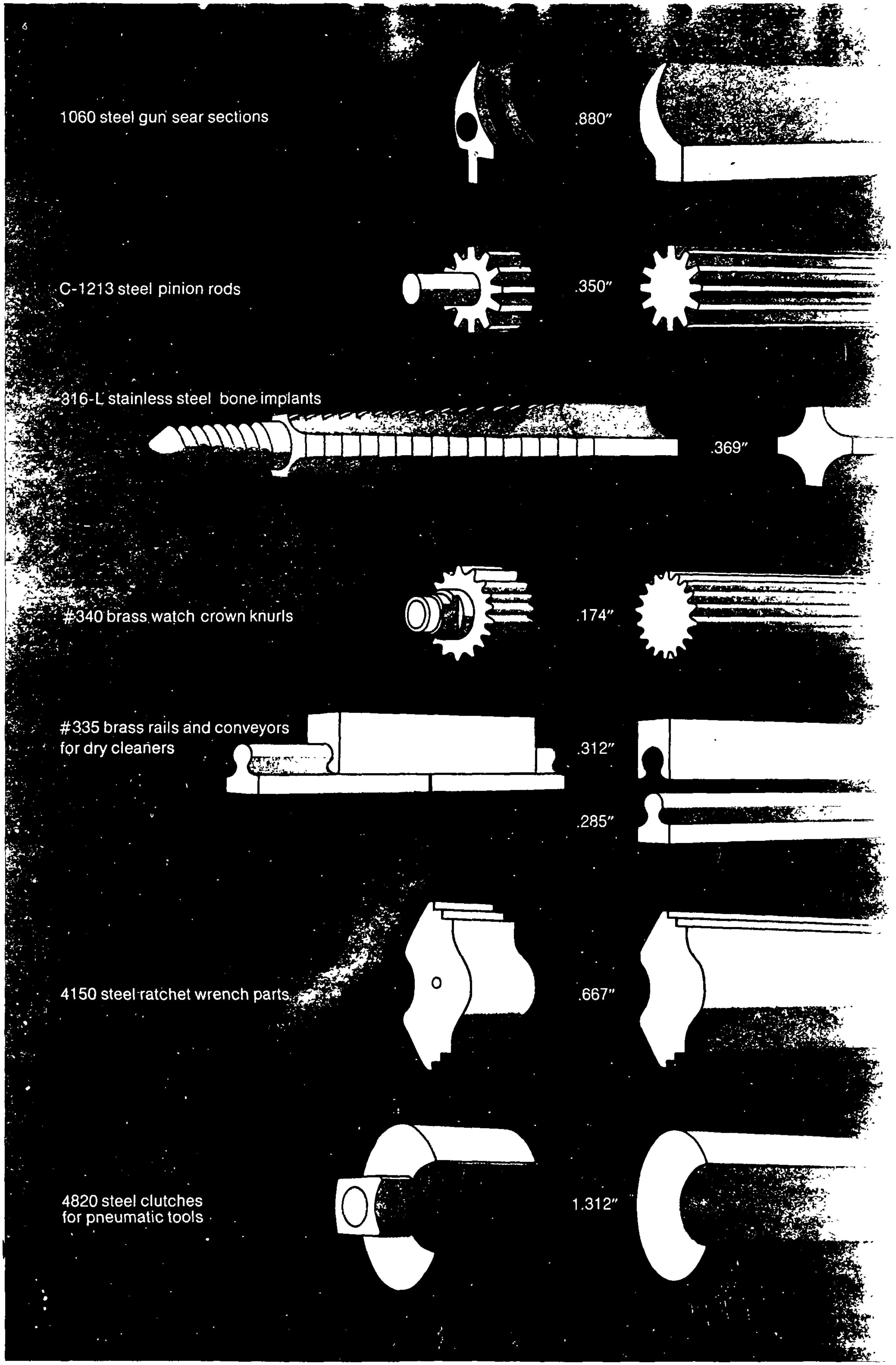


#752 nickel silver electrical



#360 brass stators for w

C-1
roll bear


1060 steel gun sear sections
.880"
C-1213 steel pinion rods
.350"
316-L stainless steel bone implants
.369"
#340 brass watch crown knurls
.174"
#335 brass rails and conveyors for dry cleaners
.312"
.285"
4150 steel ratchet wrench parts
.667"
4820 steel clutches for pneumatic tools
1.312"

In this case, round wire is rolled into a triangular shape, annealed, then worked through a series of cold drawing and annealing steps to the finished profile shape. Some shapes require as many as 20 annealing, rolling and cold drawing operations.

Process Parameters

Current size limitation is 1½″ OD down to 1/32″ OD, though 2″ is possible in brass and steels under .25 carbon. Grooves with a depth greater than one and one-half times the width (unless a generous radius is permitted at the bottom of the slot), tubular shapes with less than 5% wall tolerance and sections with holes are beyond the capabilities of the process.

Because of die costs, set-up charges and mill and furnace scheduling, profile shape orders must exceed 500 pounds; pinion rod orders, 500 pounds. Minimum orders are subject to raw stock availability.

Tolerance

The Rathbone Process can produce to closer tolerances, with greater consistency, than any other production method. Pinion rods will meet all tolerance specifications of A.G.M.A. classes one through seven. For even closer tolerances, consult with the mill.

Standard dimensional tolerance, ±.002″—can be held as low as ±.0005″ for an additional charge.

Angular tolerance, ±0°30′.

Sharp corners to .005″ maximum corner radius—to .003″ maximum for an additional charge. Leading edges of ratchet teeth require a minimum radius of .005″.

Straightness, .010″ maximum bow per foot—.005″ maximum bow per foot for an additional charge.

Twist limit for reasonably symmetrical sections, 0°30′ per foot longitudinally.

Profile shapes and pinion rods are shipped in coils or in 10′-12′ lengths cut to ¼″ tolerance—can be cut more accurately for an additional charge.

Temper

Standard temper is as-drawn. Specific temper ranges can be developed to meet customer requirements. A plus or minus five point Rockwell spread is preferred but a five point total spread can be ordered.

All metals currently being cold drawn can be annealed at finish. However, it increases the cost of straightening and makes the finished rods more susceptible to handling damage.

Drawn rods can be stress relieved for an additional charge.

If heat treatment is required, it should be done after the parts have been finish machined.

Finish

Standard finish is 63 RMS.

Rods are shipped with residual lubricant which retards corrosion and aids further fabrication. If preferred, drawing lubricant can be removed prior to shipment.

Decarb free rods are available for an additional charge. This requires special material therefore specification must be made prior to order entry.

Designing Profile Shapes

Consulting with Rathbone early in the design of component parts can pay off by eliminating production problems and by increasing part performance. We cannot recommend this procedure strongly enough. In addition, there are a few basic points to keep in mind:

1. Avoid abrupt changes in sections that introduce localized stress concentrations. Often a simple change in design will both strengthen the product and reduce its cost.
2. Avoid unnecessarily sharp corners. Be as generous with fillets and chamfers as the design will permit in order to minimize local stress areas.
3. Choose the material carefully, remembering that shapes made of easily drawn metals can be produced at a lower cost and with more precision.
4. Tell us how you plan to cut the part, how you will heat treat it and how you will finish it. Indicate the working or critical surfaces. This information will help us plan our operations for maximum savings to you.

Designing Pinions and Gears

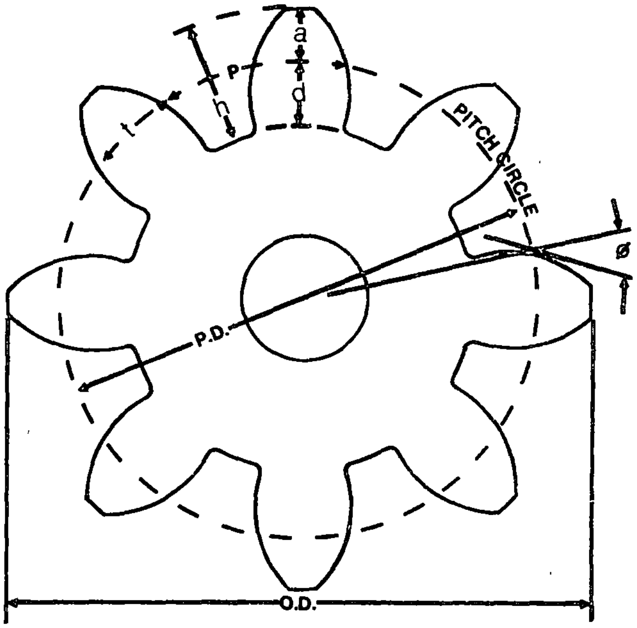
The Rathbone Process has produced all types of tooth forms including involute, cycloidal and swiss pinion. All the cost saving and precision advantages of cold drawn pinions and gears can be achieved by meeting three design stipulations:

1. Avoid all unnecessarily sharp corners. Round off the top lands of the teeth and the bottom lands of the tooth spaces.
2. Avoid excessively thin, deep teeth especially in materials which have poor cold drawing properties.
3. Avoid undercut pinions when specifying involute teeth. In fact, undercut pinions should be eliminated wherever possible regardless of the method of production since they usually prove to be troublesome.

Recommendations for machining

An important feature of cold drawn pinion rods is high dimensional accuracy. Rathbone takes extreme care in meeting tooth form and backlash requirements. Cold drawn pinion meets all tolerance specifications of A.G.M.A. classes one through seven. The process consistently produces pinion with the outside diameter, pitch diameter and root diameter concentric with each other within close limits. Therefore, it is possible in fabricating to locate from any of these diameters and have the other dimensions true with the chucking diameter.

Various factors will determine the best method of locating, such as the particular type of equipment available. Best results are obtained when collets or chucks are used which locate on the tooth profiles. The grip on the pinion rod, to resist cutting pressure, can be lighter since the collet or chuck produces "keyed engagement." On the other hand, using the outside diameter requires a much tighter grip on the outside of the bar to overcome cutting pressures and can damage the tops of the teeth.



To specify a gear, submit the following:

Number of Teeth (N)
Diametral Pitch (P)
Pressure Angle (Ø)
Outside Diameter (OD)
Pitch Diameter (PD).

Proportions of the A.G.M.A. Standard No. 207.05

$$\text{Pitch Diameter (PD)} = \frac{\text{Number of Teeth}}{\text{Diametral Pitch}}$$

$$\text{Diametral Pitch (P)} = \frac{3.1416}{\text{Circular Pitch}}$$

$$\text{Circular Pitch (p)} = \frac{3.1416 \times \text{Pitch Diameter}}{\text{Number of Teeth}}$$

$$\text{Outside Diameter (OD)} = \frac{\text{Number of Teeth} + 2}{\text{Diametral Pitch}}$$

$$\text{Whole Depth (h)} = \frac{2.200}{\text{Diametral Pitch}} + .002''$$

$$\text{Addendum (a)} = \frac{1.000}{\text{Diametral Pitch}}$$

$$\text{Dedendum (d)} = \text{Whole Depth} - \text{Addendum}$$

$$\text{Number of Teeth (N)} = \text{Pitch Diameter} \times \text{Diametral Pitch}$$

$$\text{Tooth Thickness (t)} = \frac{1.5708}{\text{Diametral Pitch}}$$

Ordering

When requesting a quotation, placing an order or seeking information concerning a specific application, please furnish the following facts:

Quantity—profile shape minimum—500 pounds, pinion rod
minimum—500 pounds subject to raw stock availability.

Material—metal and grade.

Hardness and other condition requirements.

Coils or rods. Specify rod length if other than standard mill lengths.

Dimensioned drawing with tolerances.

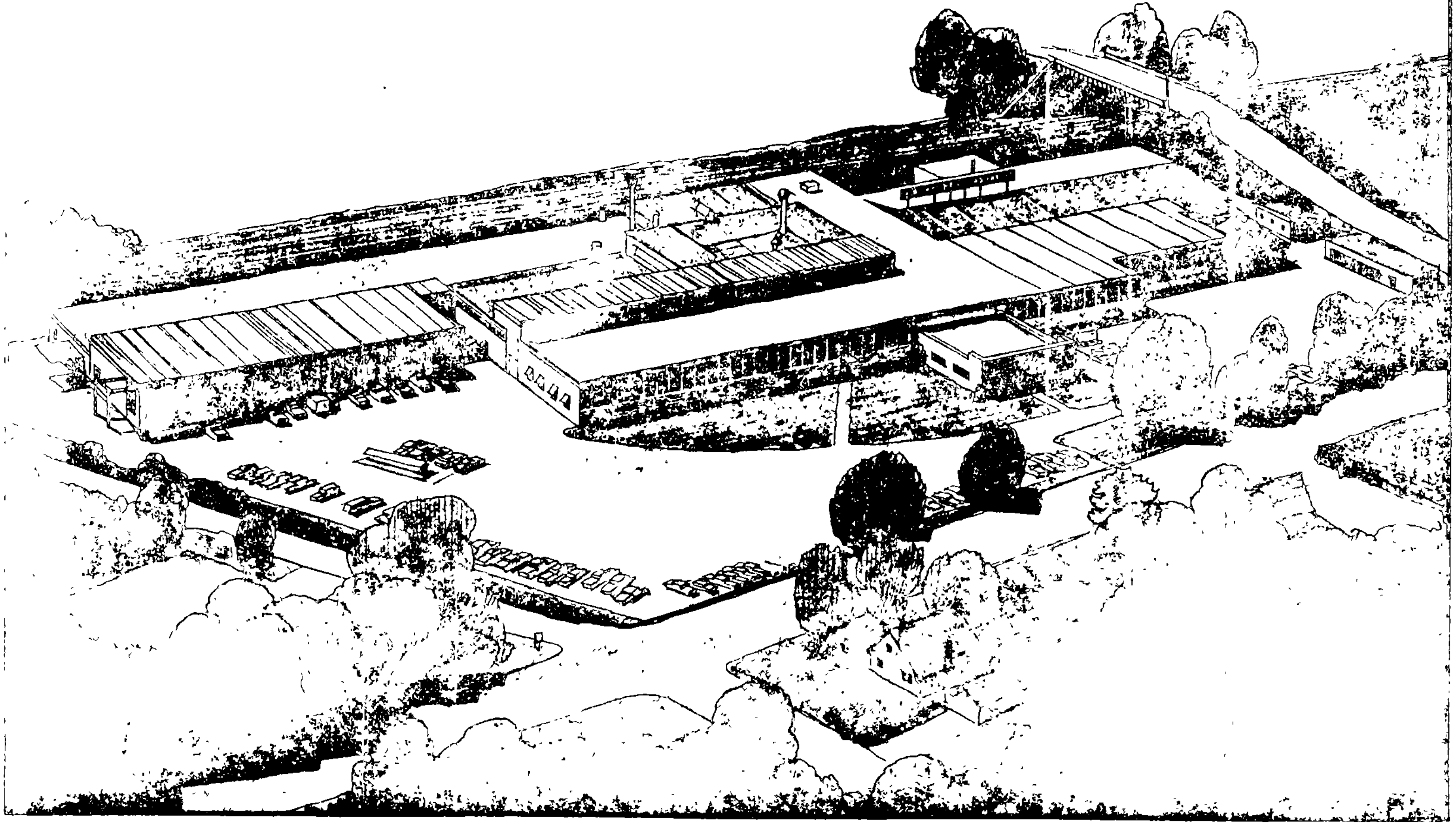
If cross section is intricate and lends itself to optical means of checking, submit a comparator layout, magnified either 20-1 or 50-1, reproduced photographically on a glass plate or on a good grade of drafting film Please do not send a sample part—an accurately dimensioned drawing is a much safer guide for precision.

All quotations and delivery dates are subject to change up to the date of order acceptance because of plant conditions and fluctuations in material and labor costs.

Title to and possession of all tools and dies, whether paid for directly or indirectly, will remain with Rathbone.

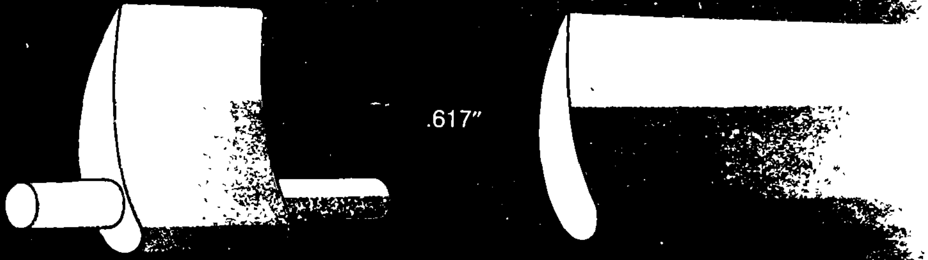
Material is guaranteed to be the best procurable. If found otherwise, it will be replaced at the option of Rathbone provided it is returned in the same condition it left the Rathbone plant. No claims for loss of labor or other damage can be allowed.

Shipments will be ±10% of the quantity ordered with variations charged or credited at the contract price. Best judgment will be exercised in routing shipments unless detailed instructions are given but Rathbone cannot be responsible for delays caused by uncontrollable conditions.

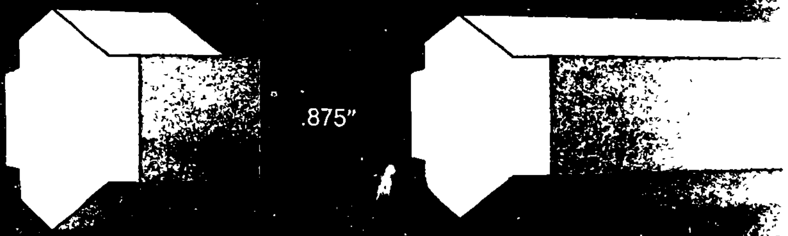


C-12L14 steel TV tuner pinions

C-1117 steel hydraulic torque converter vanes



#25 beryllium copper computer rails

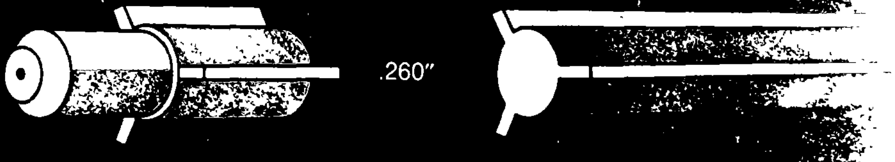


8620 steel laboratory balance scales

8620 steel gun hinges

C-1141 steel carburetor parts

#360 brass gas stove needle valves



centro de educación continua
división de estudios superiores
facultad de ingeniería, unam

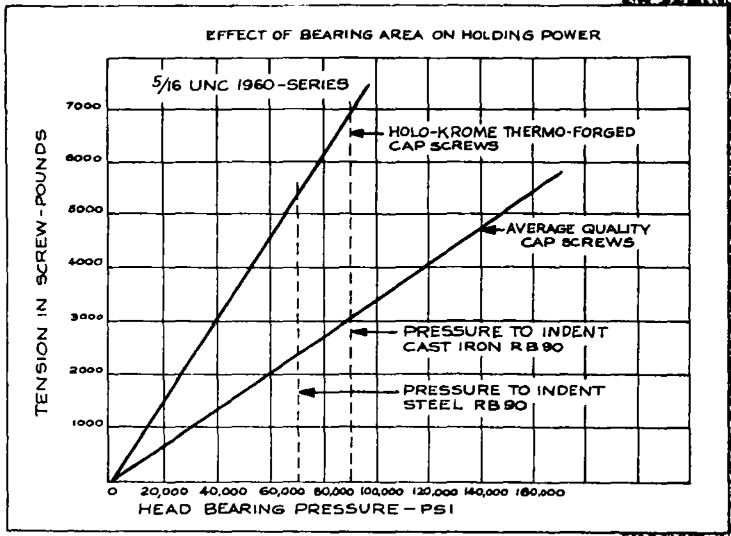
DISEÑO DE HERRAMENTAL

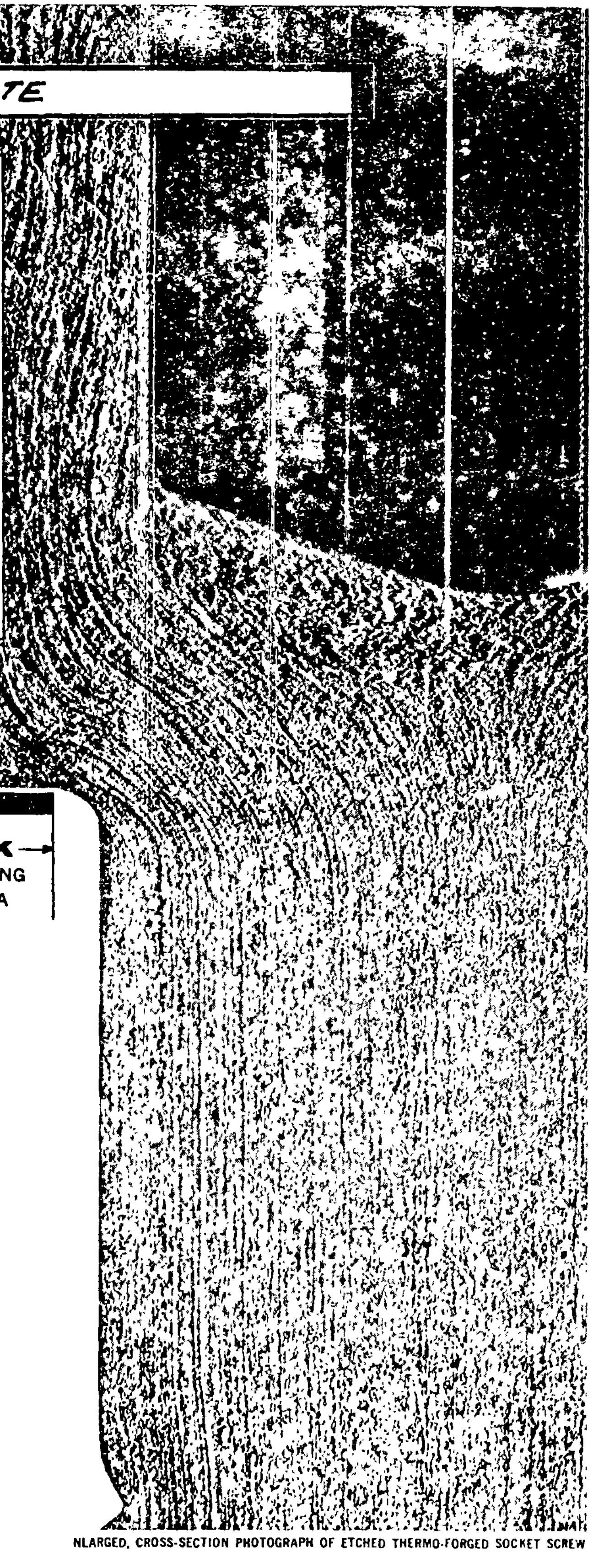
FORJA EN CALIENTE

ING. ULRICH SCHARER SAUBERLI

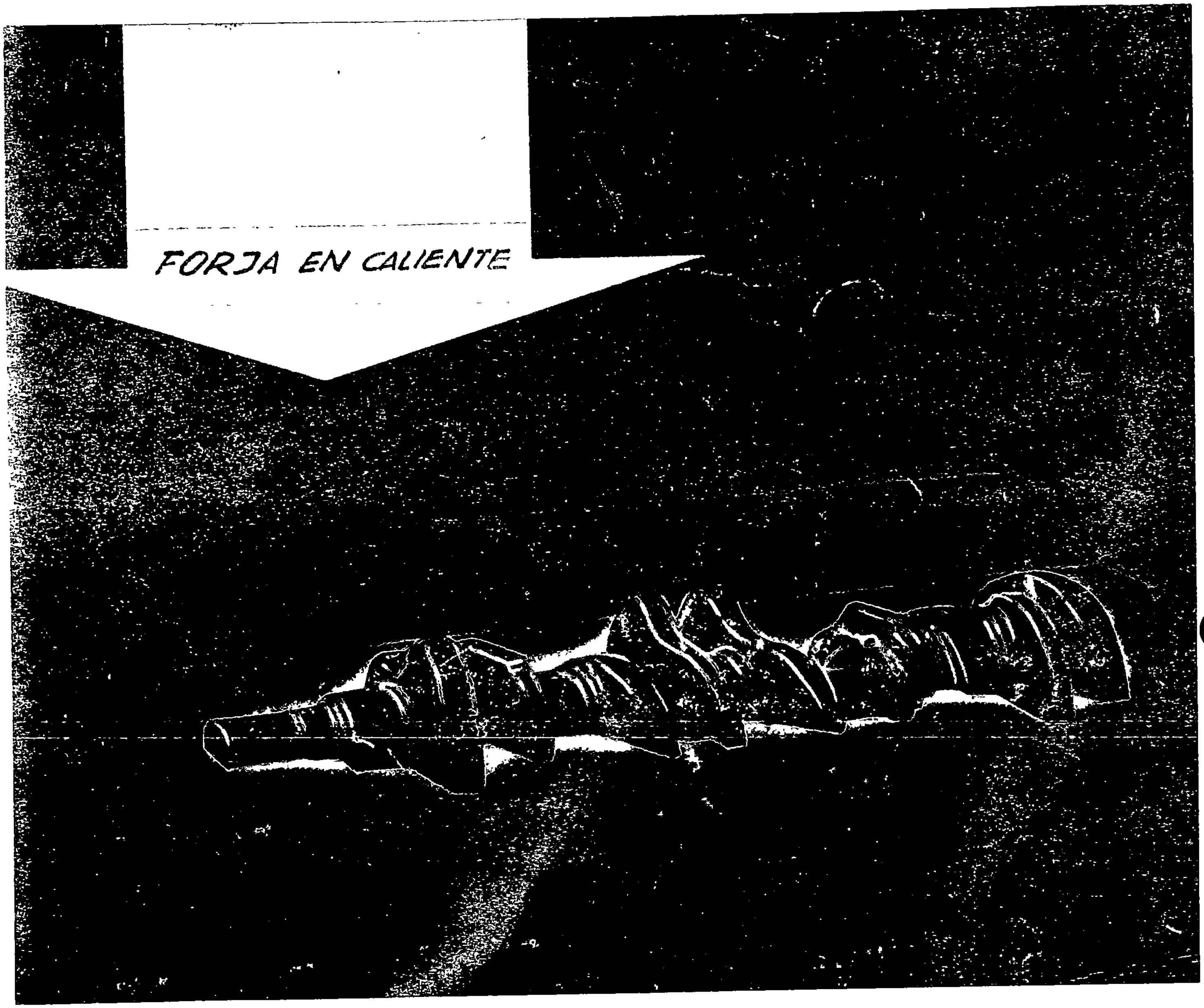
JUNIO, 1978

FORJADO EN CALIENTE

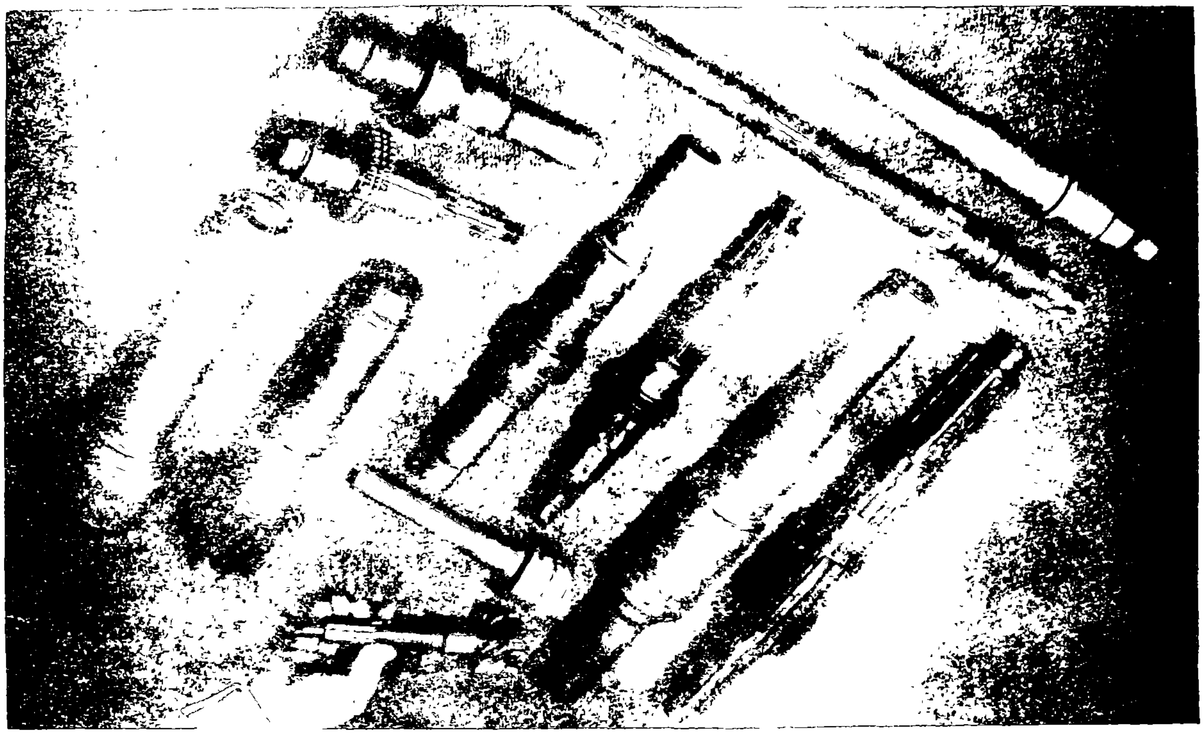


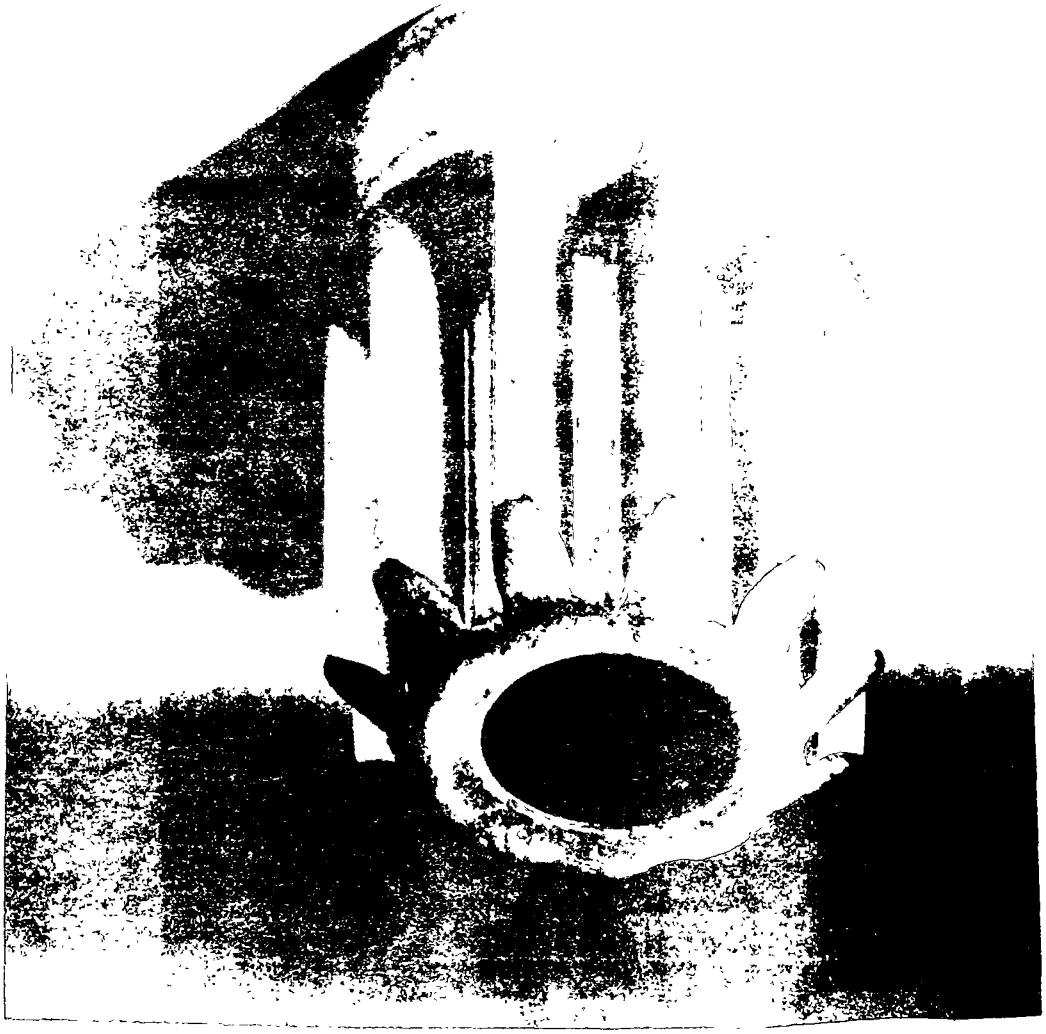


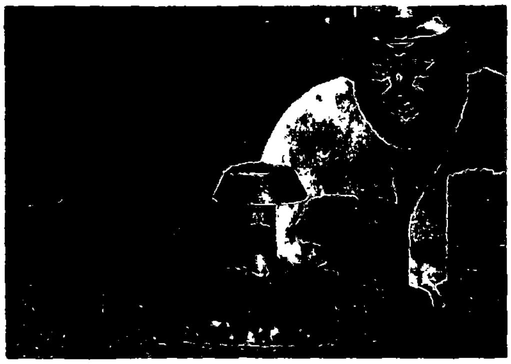
NLARGED, CROSS-SECTION PHOTOGRAPH OF ETCHED THERMO-FORGED SOCKET SCREW



FORJA EN CALIENTE

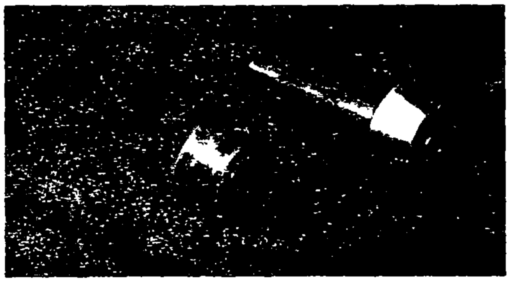






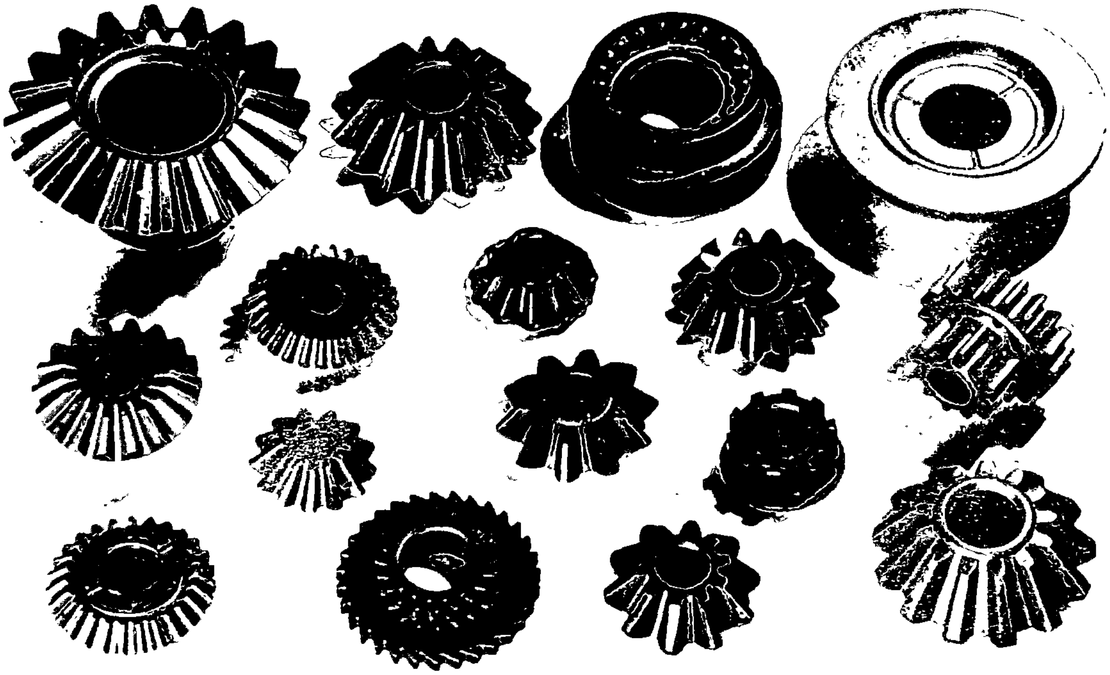
Hypoid drive pinion shaft below is shown being warm-forged by Burns Weighing 11 2 lb this 4 32-in -diam part was made from Bethlehem 8620 modified alloy steel in a multi-stage process First it was cold-formed in the press shown where it was also induction-heated and warm-forged The head formed by this process would have cracked during cold forging

Pinion shaft is shown in two stages below left as forged, right, as rough turned by customer Final use is in a light truck differential



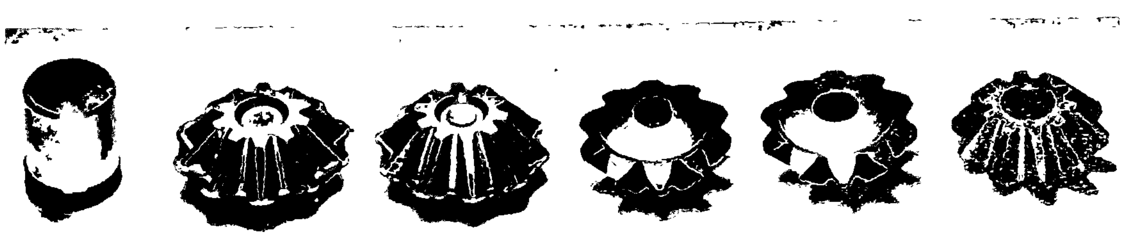
Operator, above, performs ultrasonic test on differential side gear which has been cold-upset on a press

Bethlehem supplies 8625H bars for the 8 7-lb, 3 43-in -diam part, made in two stages Shaft is shown below as shipped by Burns, left, as final-machined by customer, right Parts of this size normally are hot-forged or machined



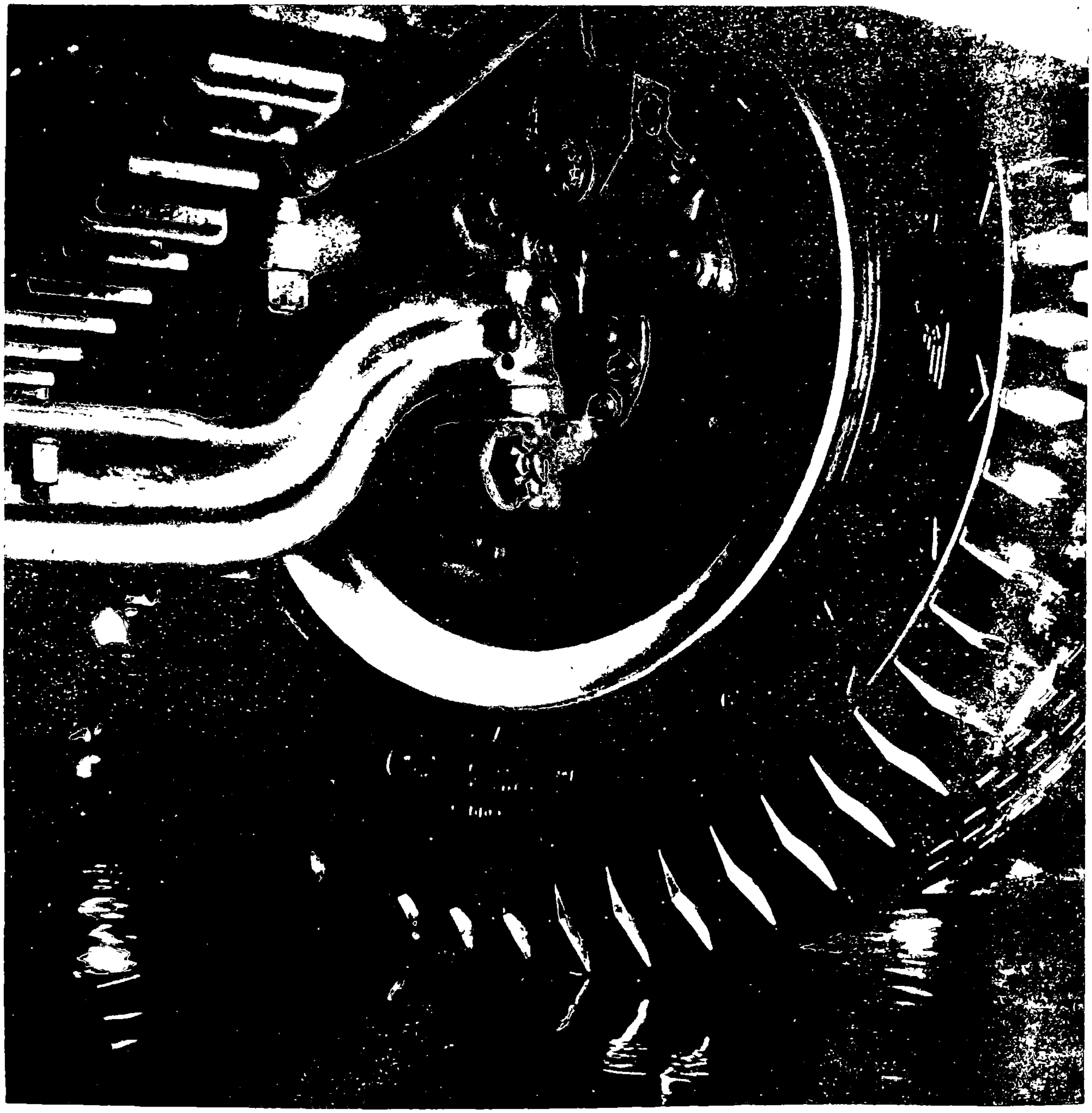
Distintos tipos de componentes, forjados en caliente

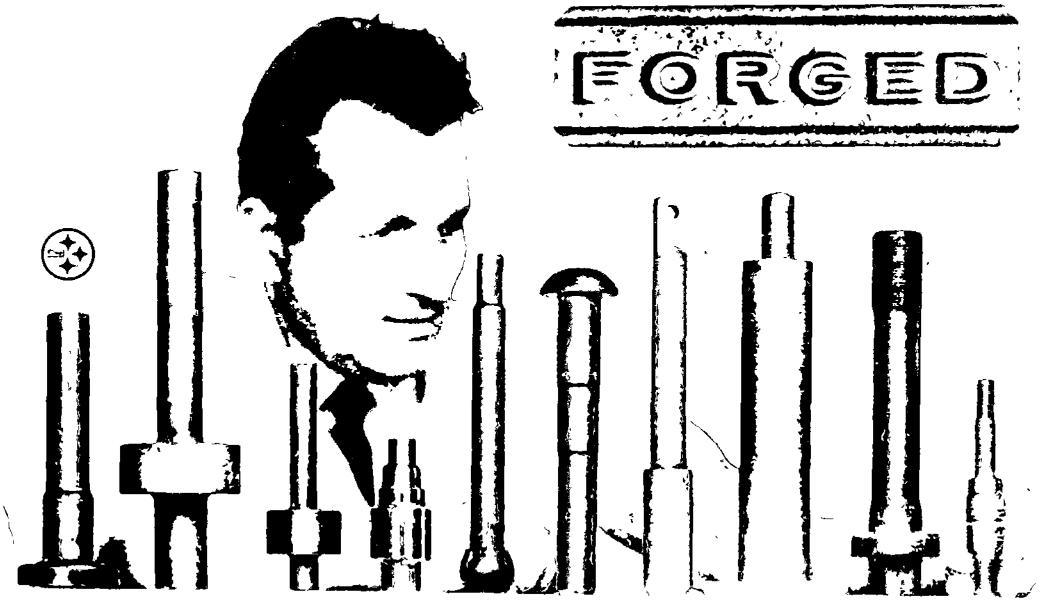
Fig. 3



Etapas del forjado

Fig. 4



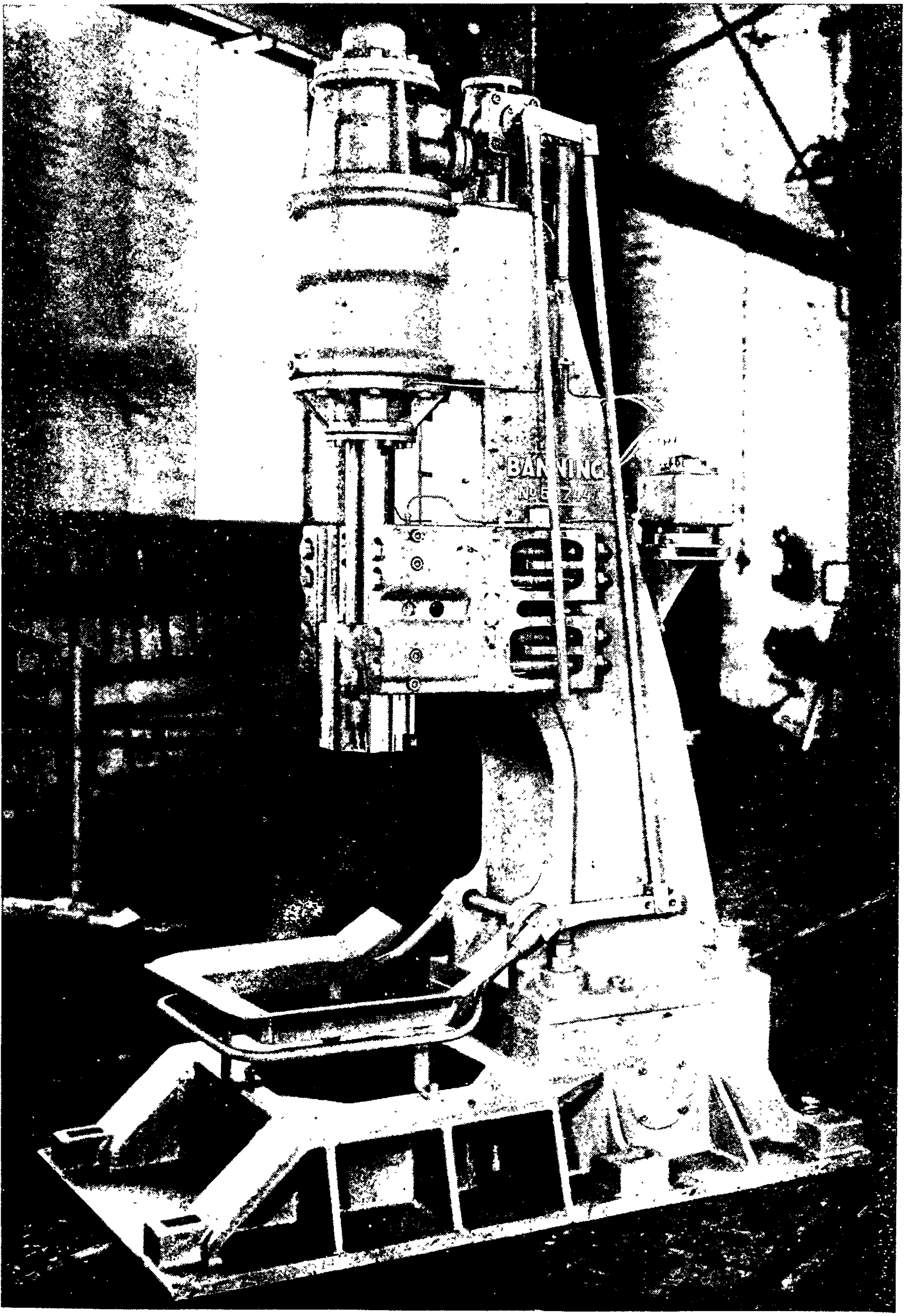

FORGED

Martillo rápido

Se emplea ventajosamente este martillo para forjar acero perfilado y barras de acero de pequeña sección transversal. El martillo es sumamente apropiado para deformar calidades de material sensibles. La máquina tiene un alto número de percusiones de 4oo-6oo golpes por minuto. En comparación con los martillos de un montante y de dos montantes antes descritos, tiene el martillo rápido una velocidad de impacto menor y, por lo tanto, una energía por golpe relativamente menor, pudiéndose así deformar de manera suave calidades sensibles de material.

Después de abrir la corredera de distribución, se lleva y saca el aire comprimido respectivamente el vapor, de forma rápida a ambos lados del émbolo, encargándose de esta operación la corredera dirigida por la maza del martillo. Gracias a la corta carrera de la maza se trabaja con un vástago de émbolo de construcción compacta y casi irrompible.

Martillo rápido



Martillo de un montante

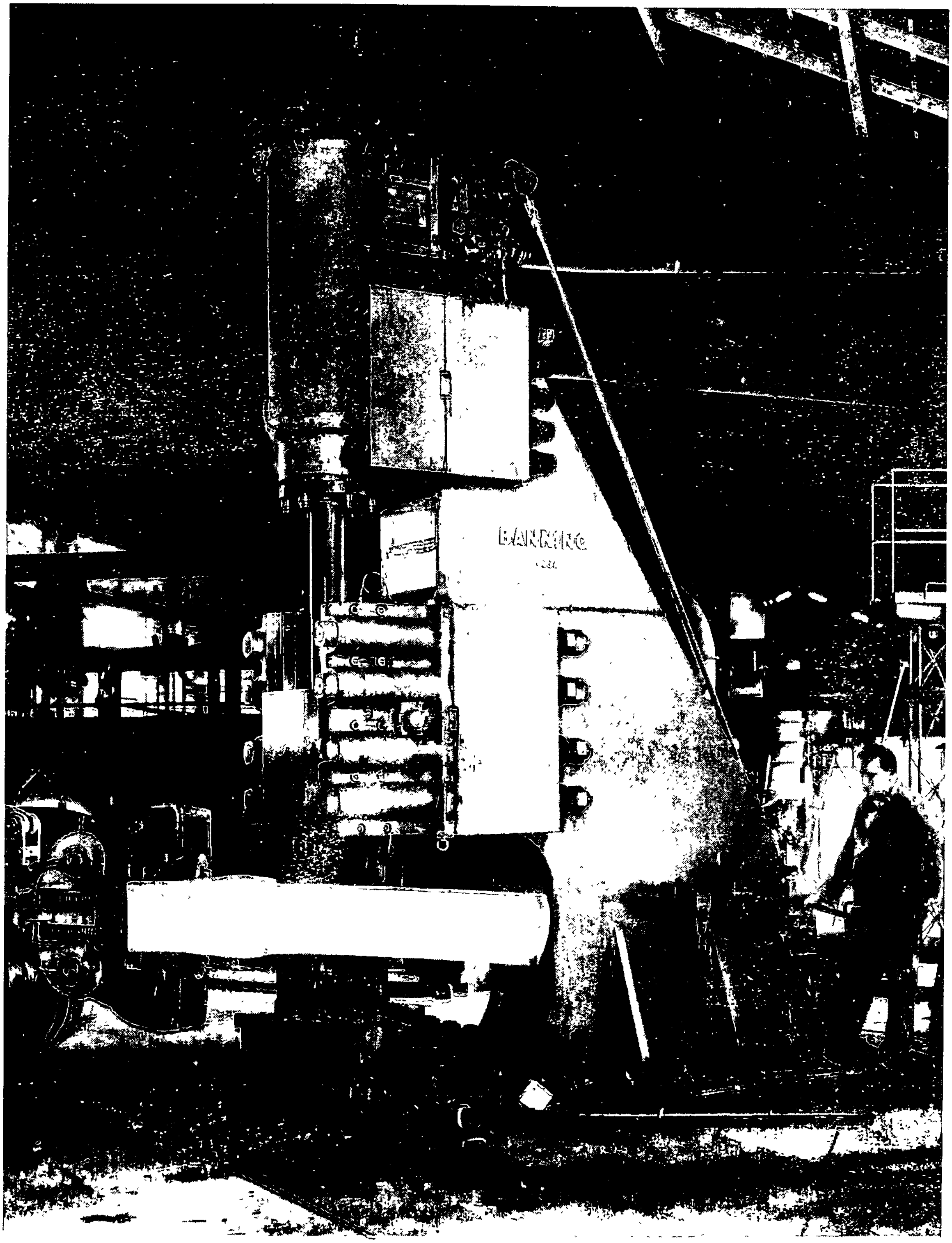
En el margen de construcción mediano y pequeno se emplea con preferencia el martillo de un solo montante. El espacio de trabajo, libre hacia tres lados, permite una forja rápida en las vías de extender y aplanar.

Para la producción de barras de acero se equipa el martillo con mando automático de percusión en serie. De esta forma puede dirigir el operario el martillo suavemente y sin esfuerzos, especialmente para trabajos de aplanar, para los cuales se precisa una sucesión rápida de golpes livianos.

Para la producción de piezas forjadas sin matrices se equipa el martillo con nuestro mando de cuatro válvulas, con el cual el operario puede trabajar con golpes individuales exactamente dosificados, pero también con una sucesión de impactos con la rapidez necesaria.

De acuerdo a la carga mecánica especial a que está sometido el martillo de on montante, se sujeta éste al fundamento de forma simétrica con fuertes anclajes.

Martillo de un montante



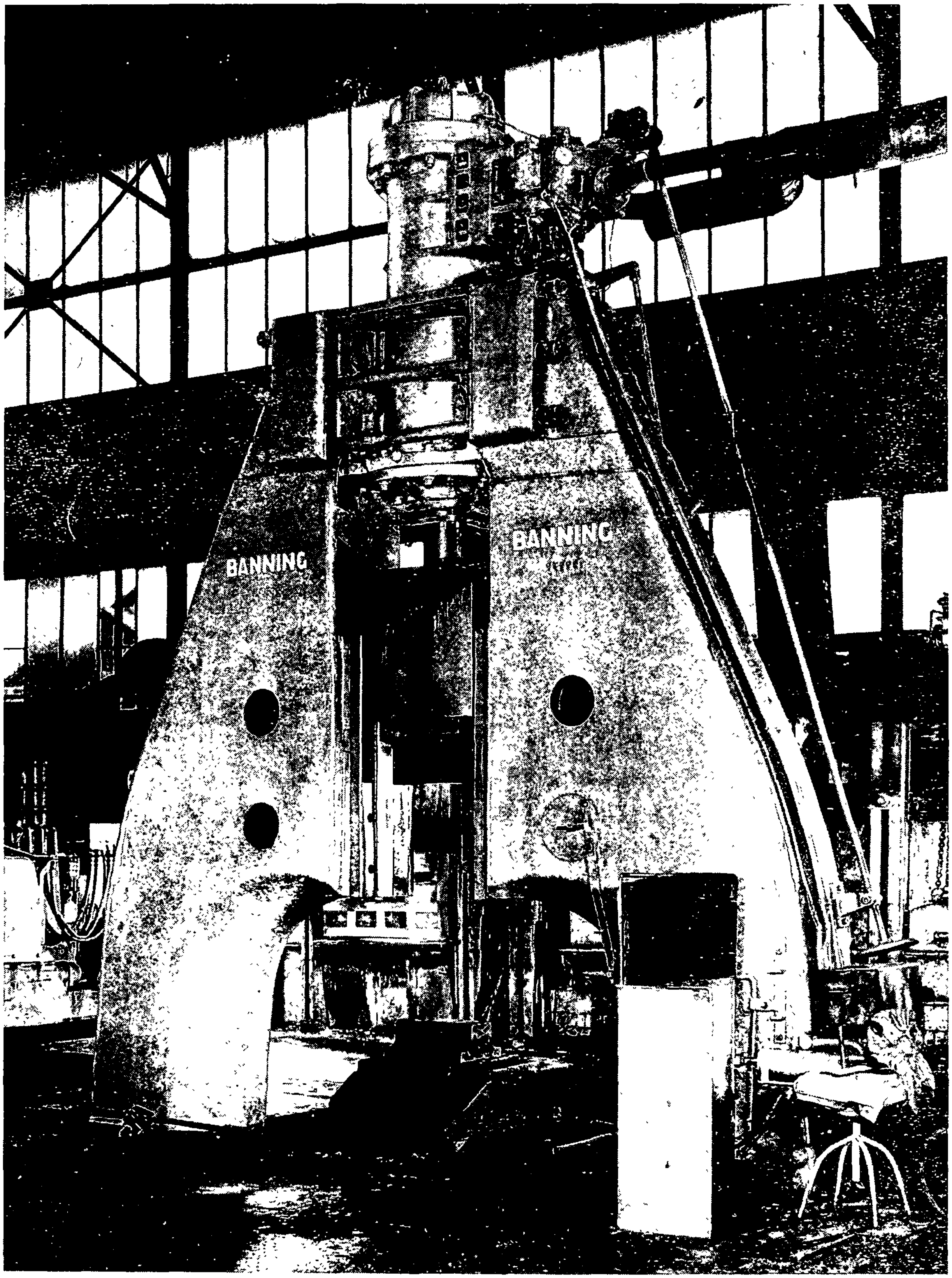
Martillo de dos montantes

Se emplean estos martillos especialmente para la producción de barras de acero. Gracias a la rápida sucesión de los impactos se puede forjar con ligereza a una temperatura materias sensibles a la temperatura. Esta construcción es, por lo tanto, adecuada para forjar especialmente aceros afinados y altas aleaciones, dentro de los tamaños medianos de martillos.

La construcción de dos montantes confiere al martillo una forma simétrica que tiene la ventaja de una gran estabilidad. Así se posibilita un funcionamiento seguro y casi libre de entorpecimientos, aún en las condiciones más duras.

Los montantes tienen una forma cónica hacia la zona de forja, lo que permite acercar mucho la tenaza de manipulación al apoyo de forja é introducir muy bien las herramientas de forja necesarias.

Martillo de dos montantes



Martillo de puente

Este martillo tiene un gran campo de acción que abarca desde la producción de piezas grandes forjadas sin matrices hasta ejes grandes, barras, discos y anillos.

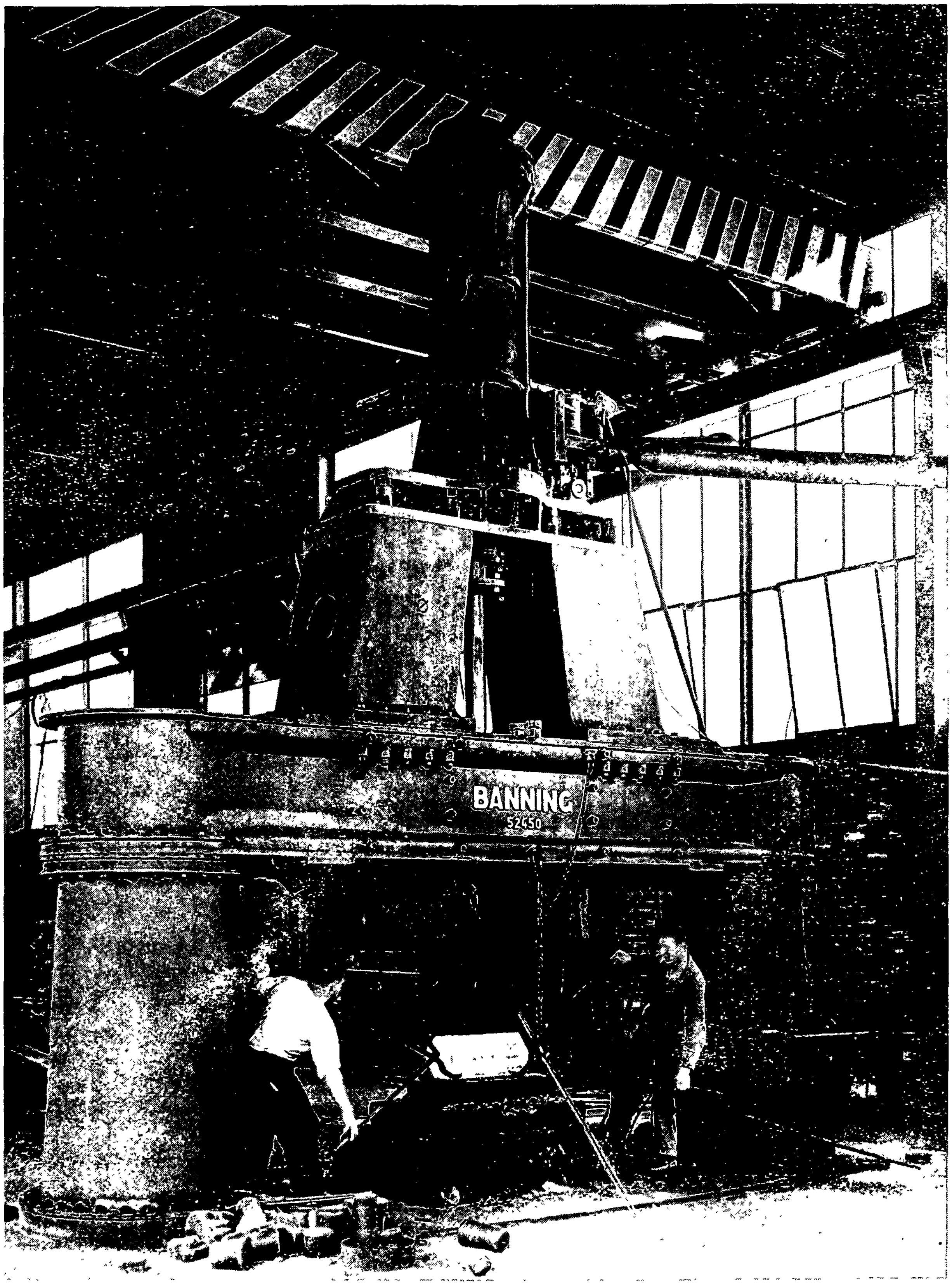
El martillo de puente tiene una carrera de maza muy larga, lo que confiere una alta energía de impactos, aún en caso de altas operaciones de recalcado y también si se trabaja con pieza de forja de gran tamaño, en cuyos casos se obtiene, empero, una gran sucesión de impactos, gracias al mando de válvulas que se abren y cierran rápidamente.

La distancia entre las columnas del caballete de martillo y la altura del puente ofrecen un gran espacio de trabajo. Este espacio libre ofrece, además, la ventaja de que las radiaciones de calor de las voluminosas piezas de forja no ejercen una influencia perjudicial sobre los componentes del martillo.

Las columnas, el puente, las placas de asiento y los montantes del martillo son de una construcción soldada, sumamente fuerte de acero. Puesto que la maza y el puente tienen la misma dilatación bajo las influencias de calor, permanece casi constante la holgura de guía entre la maza y los montantes en cualquier situación de recalentamiento. Así se obtiene la alta precisión de guía para la maza. Para facilitar los montajes y desmontajes, se sujeta el vástago de émbolo a la maza con un cierre de chaveta.

En las columnas del martillo se puede colocar soportes virables para herramientas.

Martillo de puente



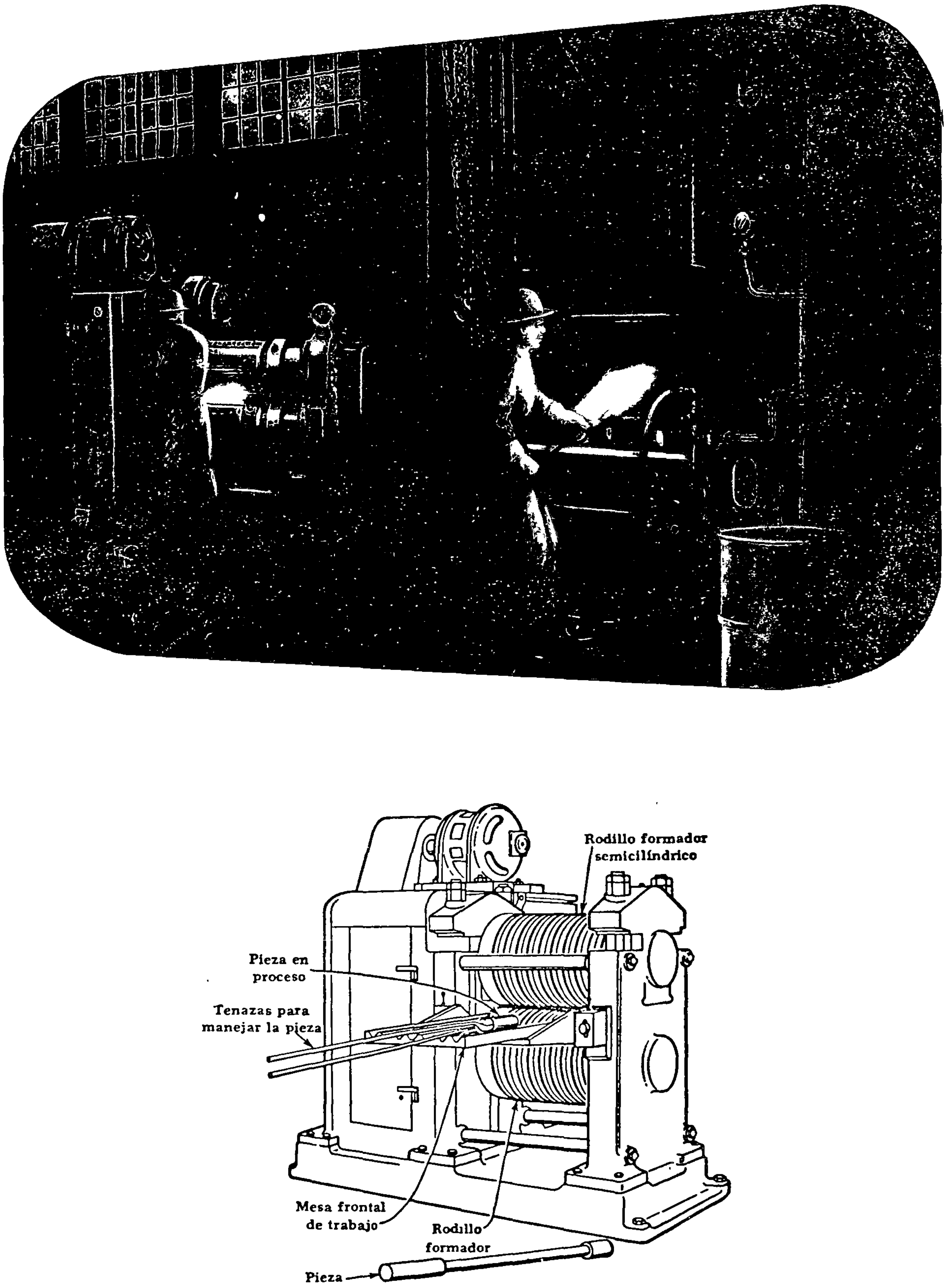
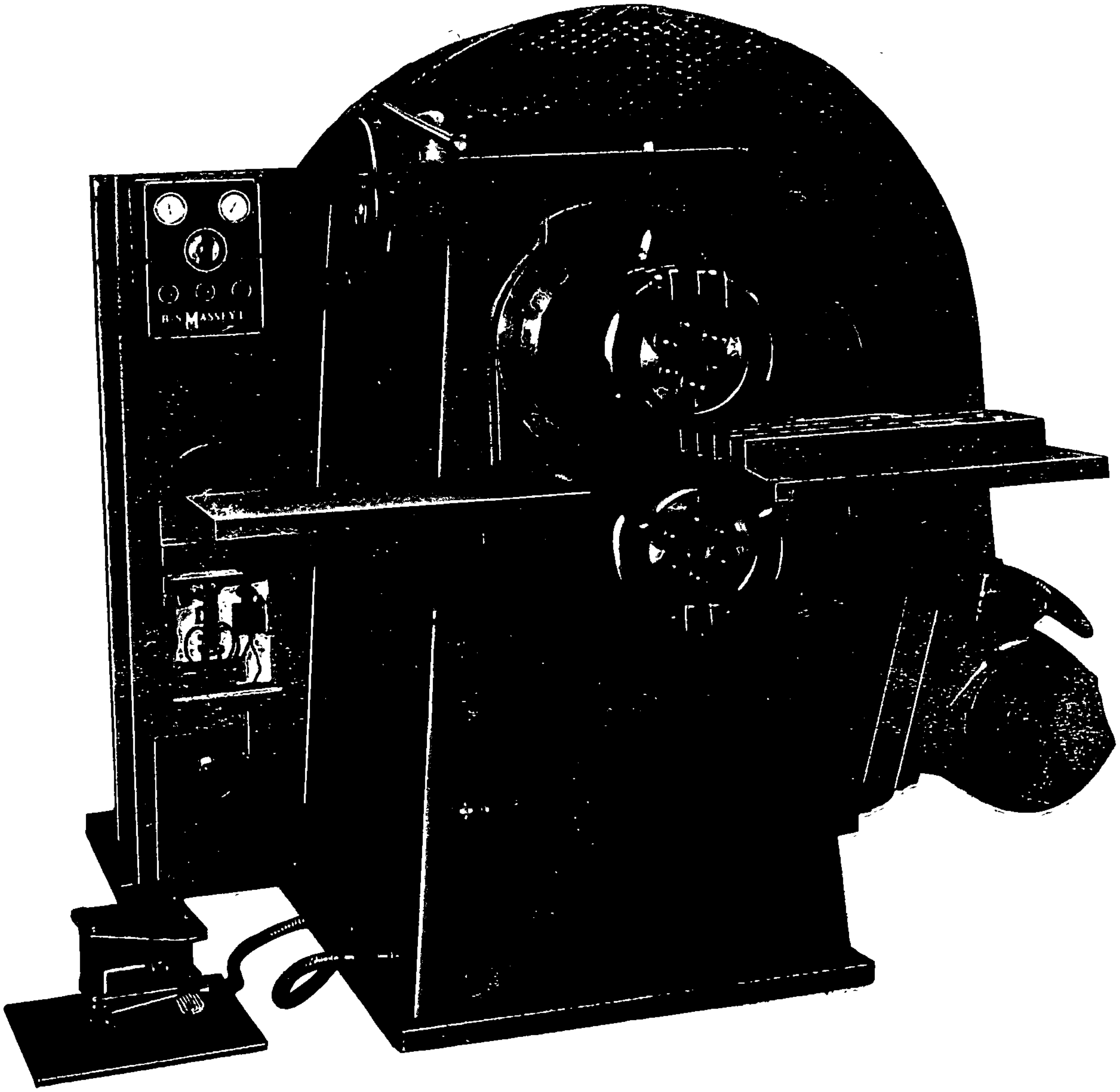
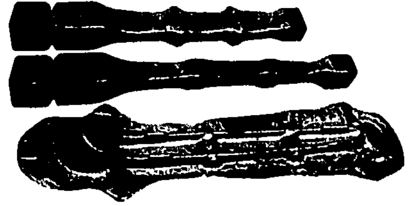
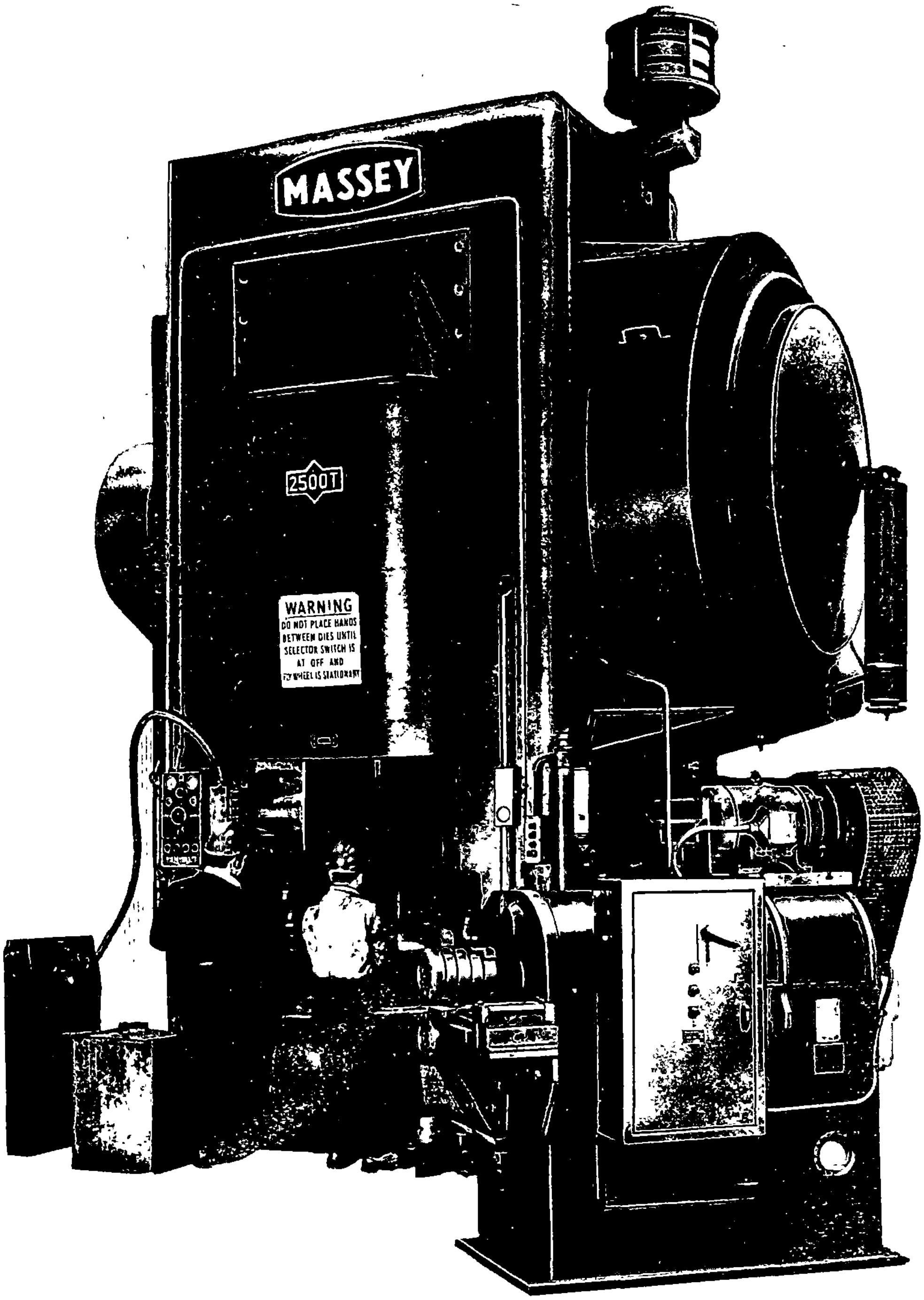
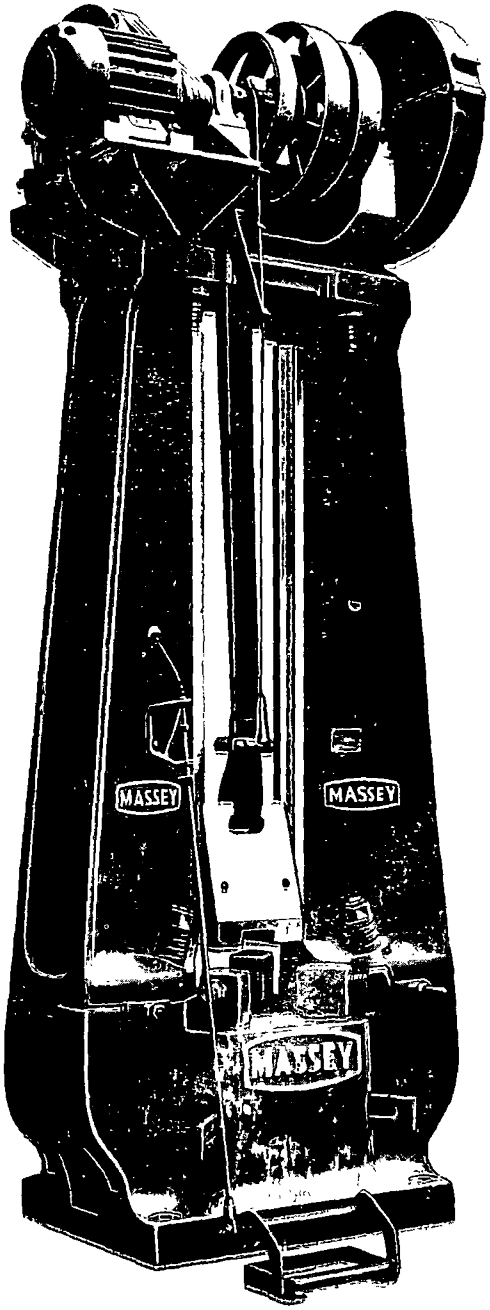


FIG. 10. Rodillos forjadores produciendo una flecha motriz de eje posterior, para automóvil. (Cortesía de The Ajax Manufacturing Company)


B.S MASSEY




MASSEY
2500T
WARNING
DO NOT PLACE HANDS
BETWEEN DIES UNTIL
SELECTOR SWITCH IS
AT OFF AND
FLYWHEEL IS STATIONARY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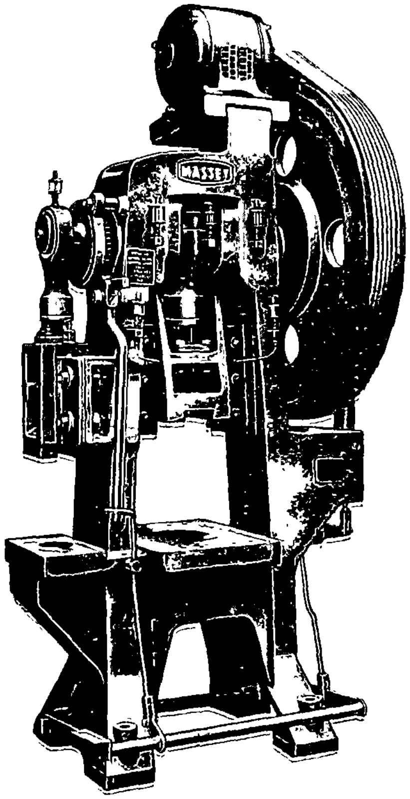
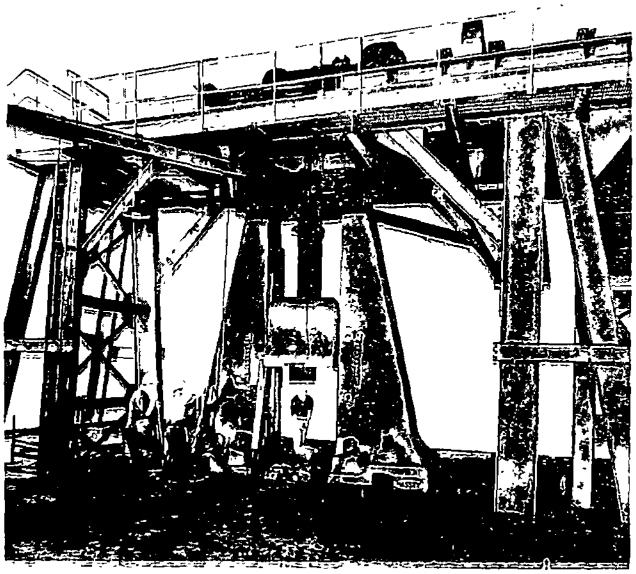
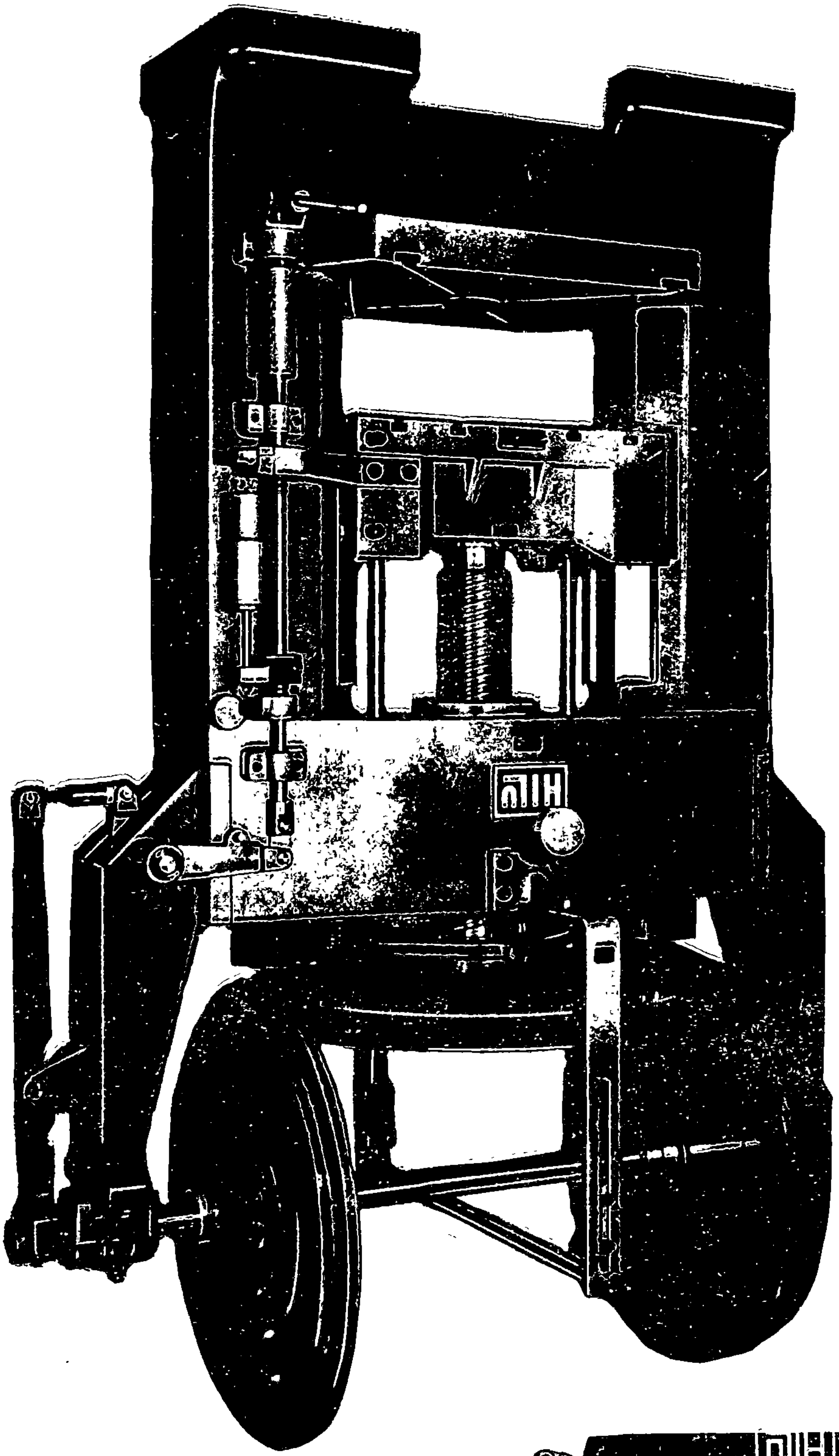
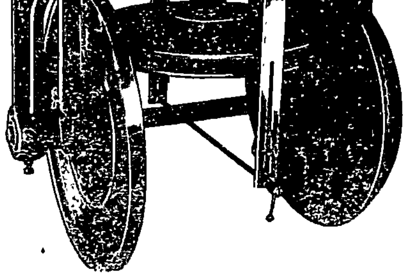
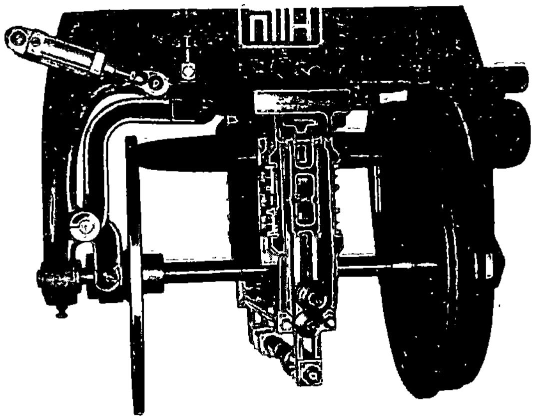

MASSEY







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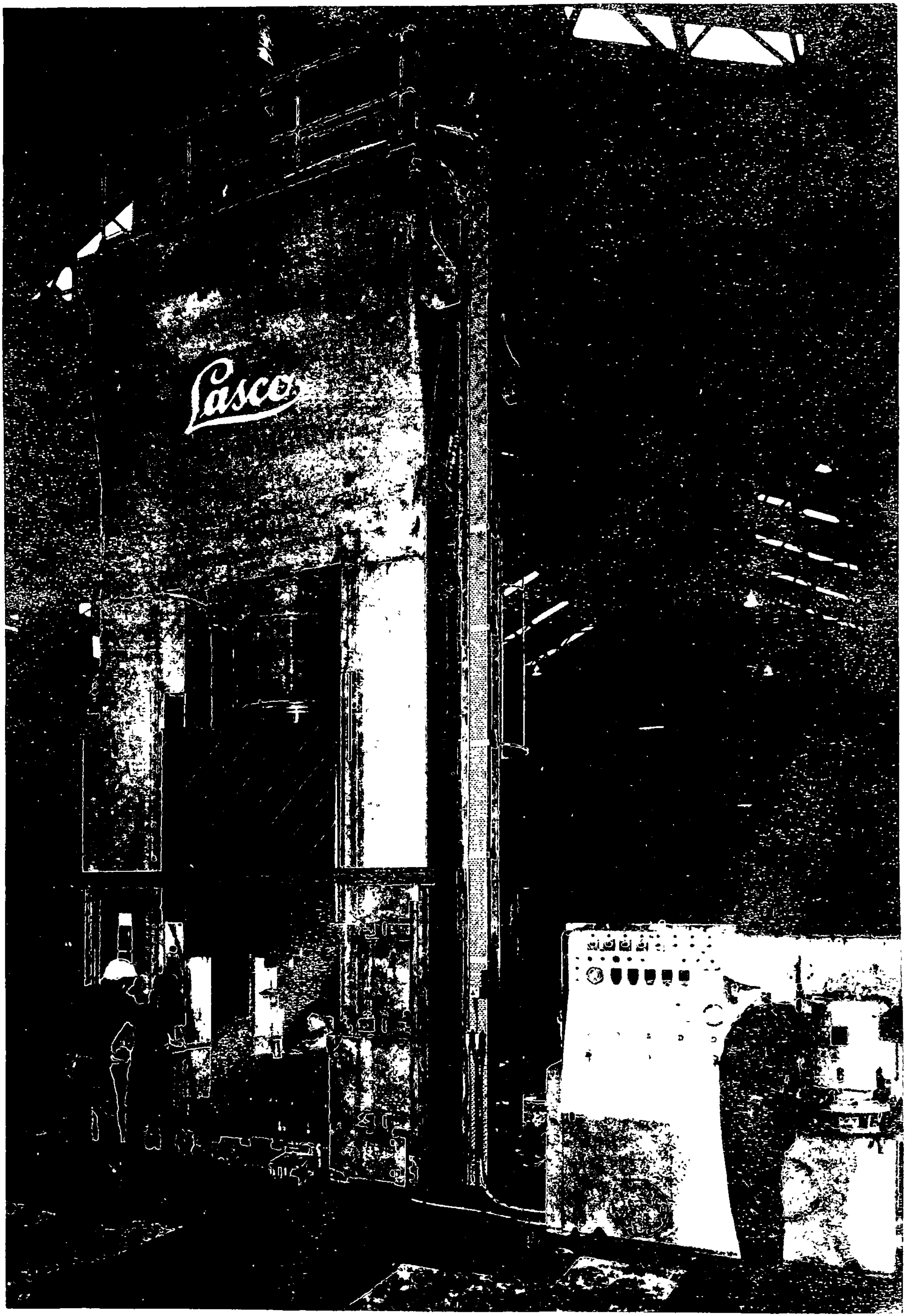
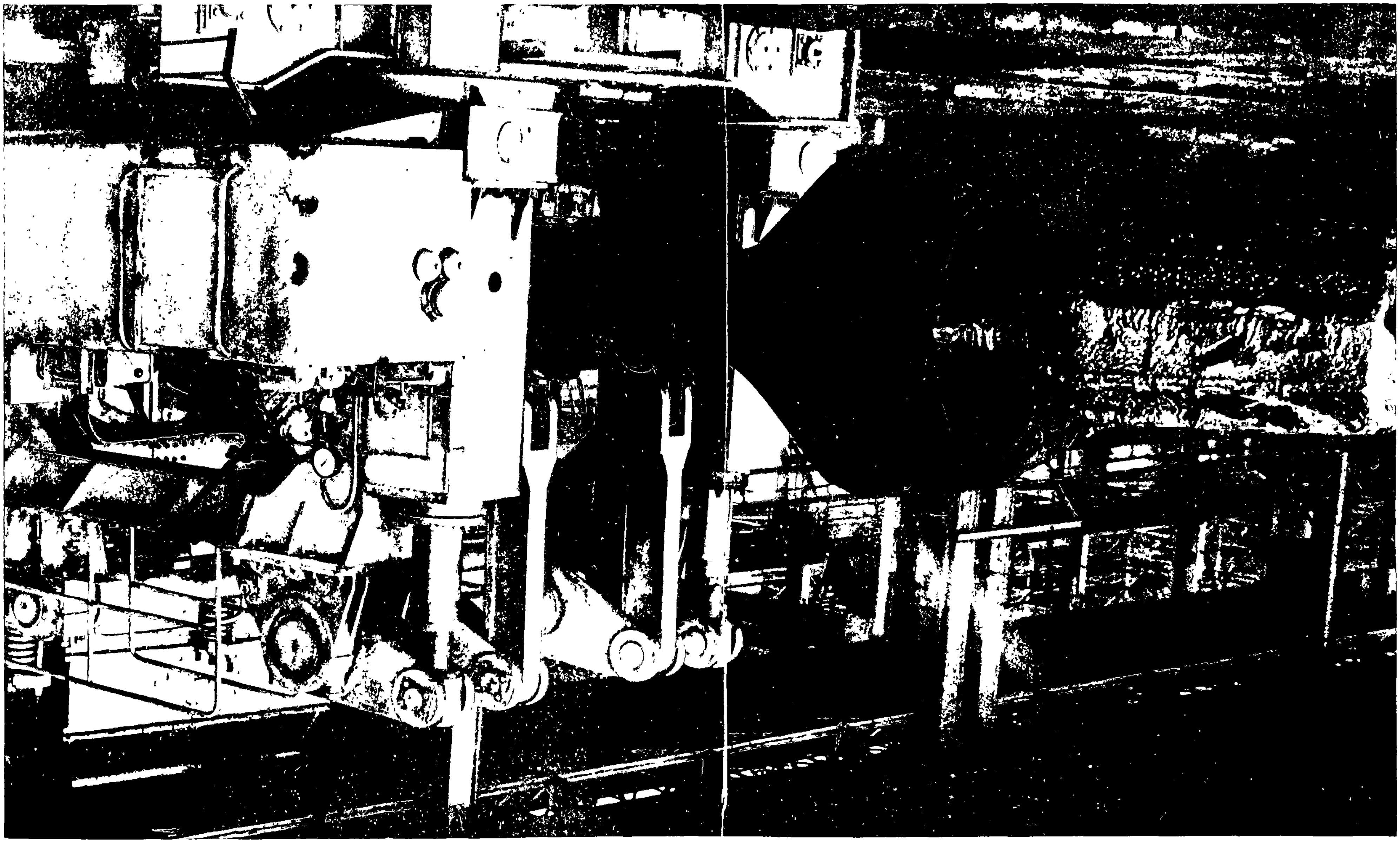
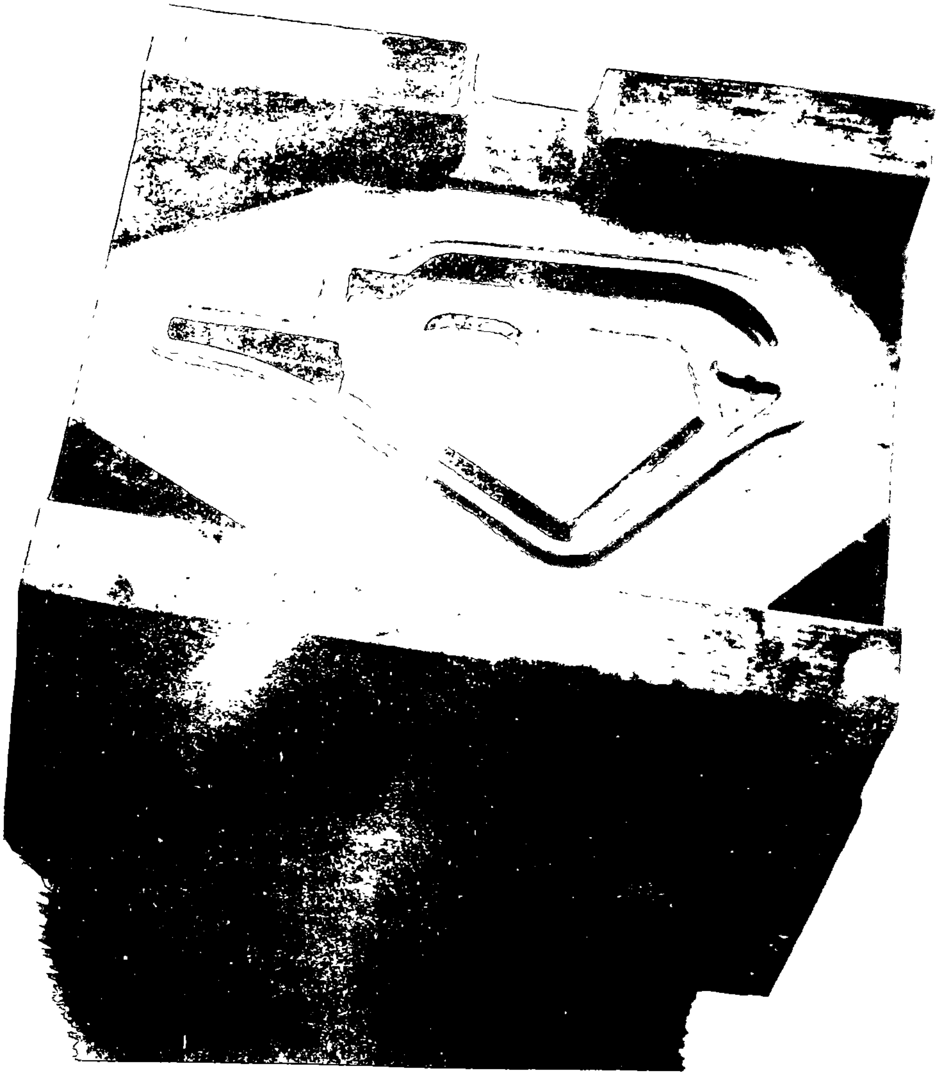
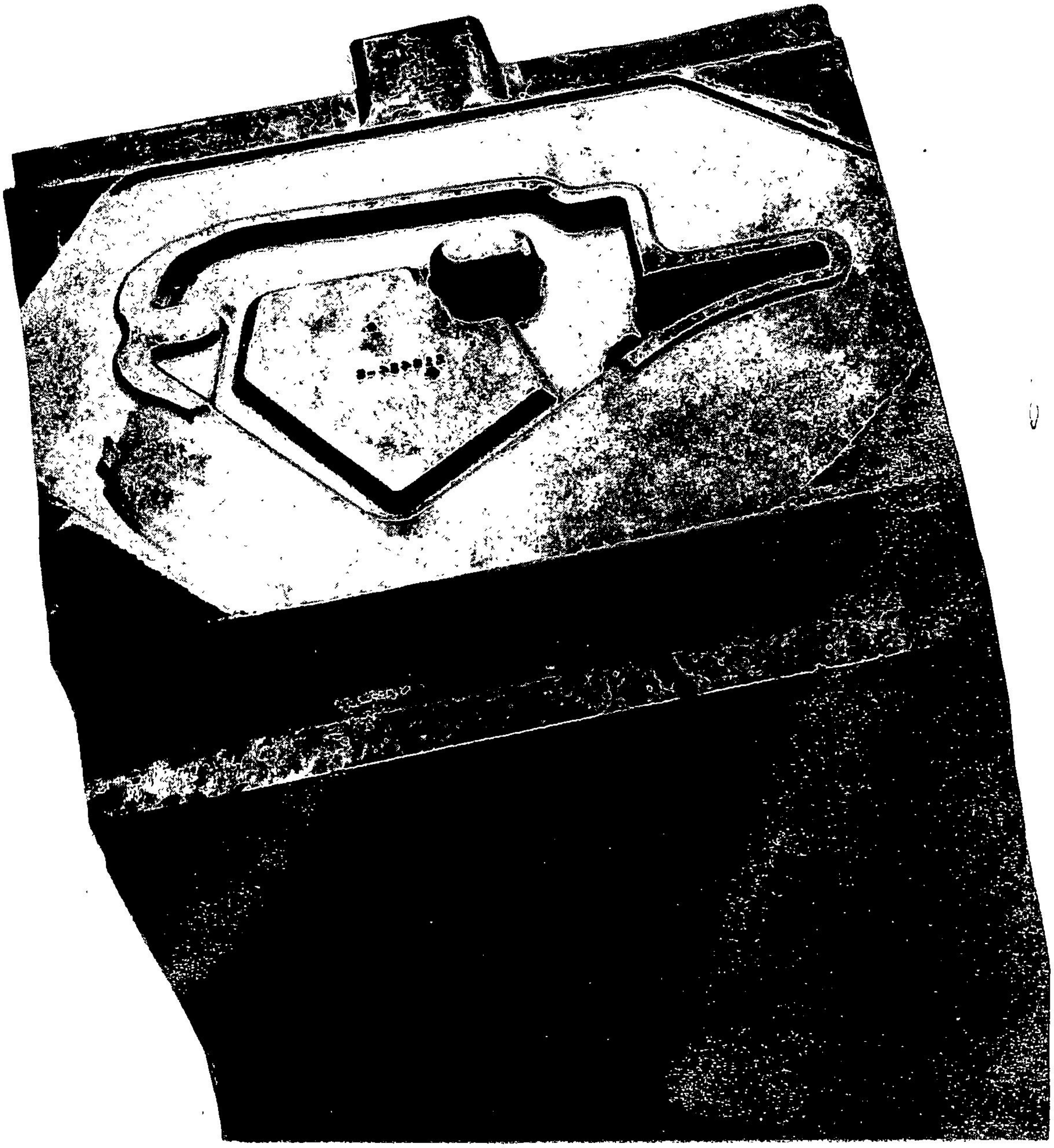

Lasco


KARL FOSTER



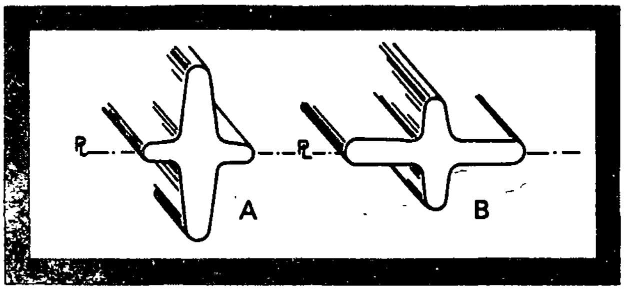


With precision that is constant part to part and lot to lot, these forging dies shape plow beam heads from Republic C-1050 Forging Quality Carbon Steel. The part is forged for the Oliver Corporation by Standard Forgings Division, Standard Alliance Industries, Inc.

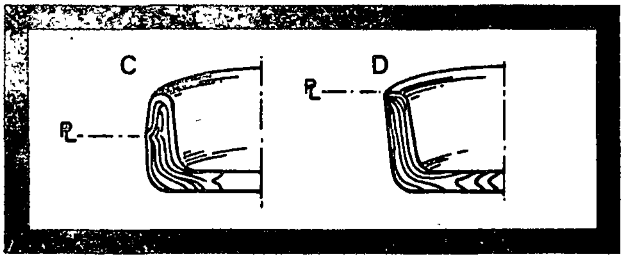


I. PARTING LINE:

Selection of parting line is one of the most important design decisions to be made. The best choice simplifies removal of the part from the dies, helps provide optimum grain flow advantages, reduces material requirements, and increases die life by reducing forging pressures.



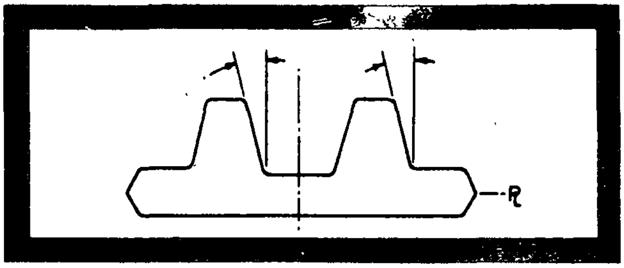
Question 1:
Why is the parting line location in example B preferred rather than the location in A?



Question 2:
Why is the parting line position shown in example D preferred over that in example C?

II. FORGING DRAFT:

Forging draft is necessary on almost all types of steel forgings to permit removal of the forging from the dies and, in certain instances, to achieve the desired metal flow.

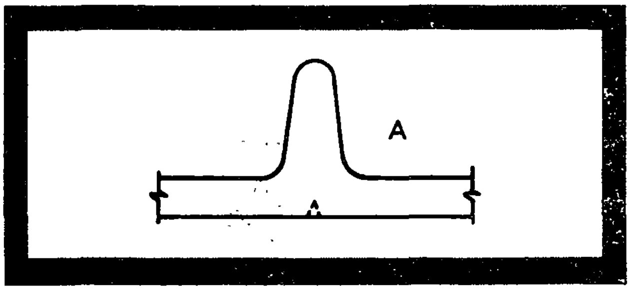


Question 3:
What are the draft angles commonly used in forged steel part design?

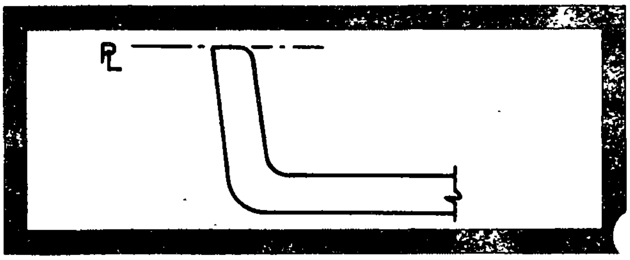
Question 4:
Why can outside draft angles often be smaller than inside draft angles?

III. RIBS AND WEBS:

A web is a thin part of a forging lying in or parallel to the forging plane. A rib is a thin section perpendicular to the forging plane.



Question 5:
Does reduction of rib or web thickness significantly reduce weight of a finished forging?



Question 6:
Generally speaking, should ribs be thicker than webs?

Answer 1:
The preferred choice avoids deep impressions that promote die wear and require higher forging pressures.

Answer 2:
The preferred parting line produces the most desirable grain-flow pattern.

Answer 3:
6° to 7°.

Answer 4:
Because outside surfaces tend to shrink away from the dies during cooling, simplifying removal of the forging.

Answer 5:
Yes — particularly on tall ribs or large webs where even small reduction in thickness accounts for sizable weight savings.

Answer 6:
No — webs should be equal or greater in thickness than ribs to avoid forging difficulties.

H - 27

500···10000 Hz MITTELFREQUENZ-WÄRMEBEHANDLUNG

Prinzip:

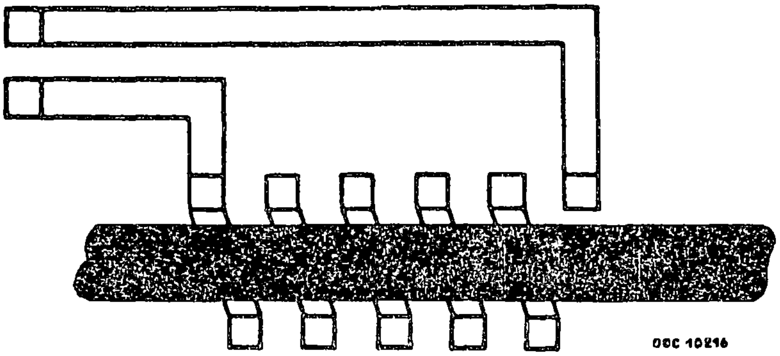
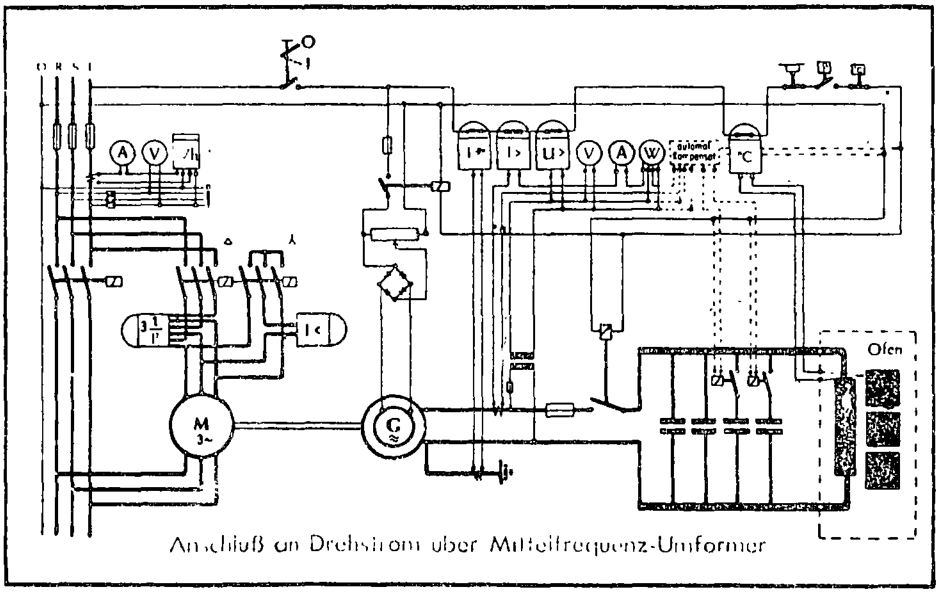


Bild 46

Das metallische Gut erwärmt sich als Sekundärwiderstand eines Einphasen-Lufttransformators. Die Ausdehnung der Erwärmungszone ist von der Frequenz, der Leistungskonzentration und der Einwirkungszeit bei gegebenen Abmessungen abhängig. Alle Zwischenstufen von der vollständigen Durchwärmung für Schmiede- oder Preßvorgänge bis zur Oberflächenerwärmung für Oberflächenhärten sind erreichbar! Anschluß über Umformer an Drehstrom. Kompensation durch Kondensatorbatterie.

Schaltung:



Anschluß an Drehstrom über Mittelfrequenz-Umformer

Bild 47.

Voraussetzung zur Anwendung:

Kleinste Abmessungen für Durchwärmung. Kleinste Einhärtetiefe 1,5···2 mm.

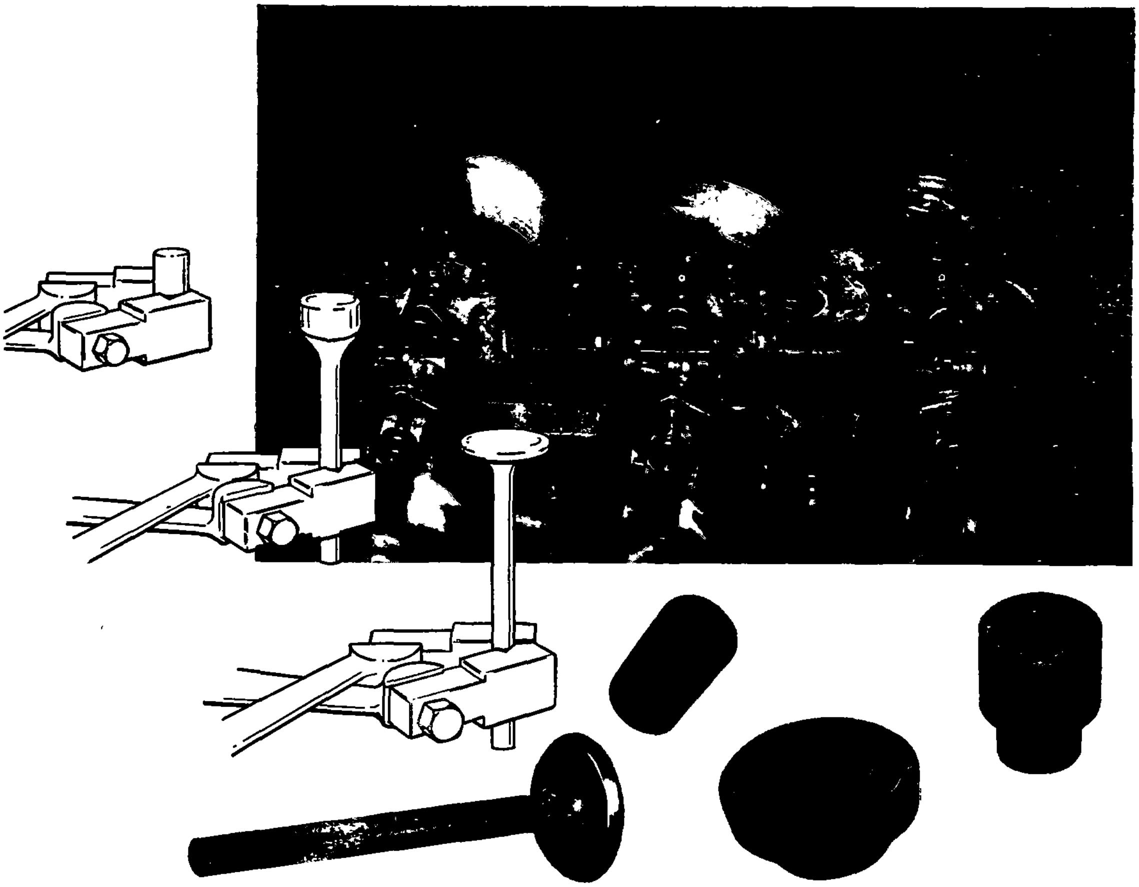
VORTEILE

Nahezu zunderfreie Erwärmung · Gute Anpassungsfähigkeit an vorhandene Abmessungen · Ausgezeichnete Regelmöglichkeit · Reproduzierbare Vorgänge durch automatische Spannungskonstanthaltung und Zeitschaltglieder · Vielseitige Einsatz- und Ausnutzungsmöglichkeit · Leichte Einfügung in fließbandähnliche Fertigung · Geringer Platzbedarf durch Aufstellung des Umformers und der Hauptschaltanlage im besonderen Raum.

NACHTEILE

Aufstellung eines Umformers.

Hot-forming on horizontal mechanical press.



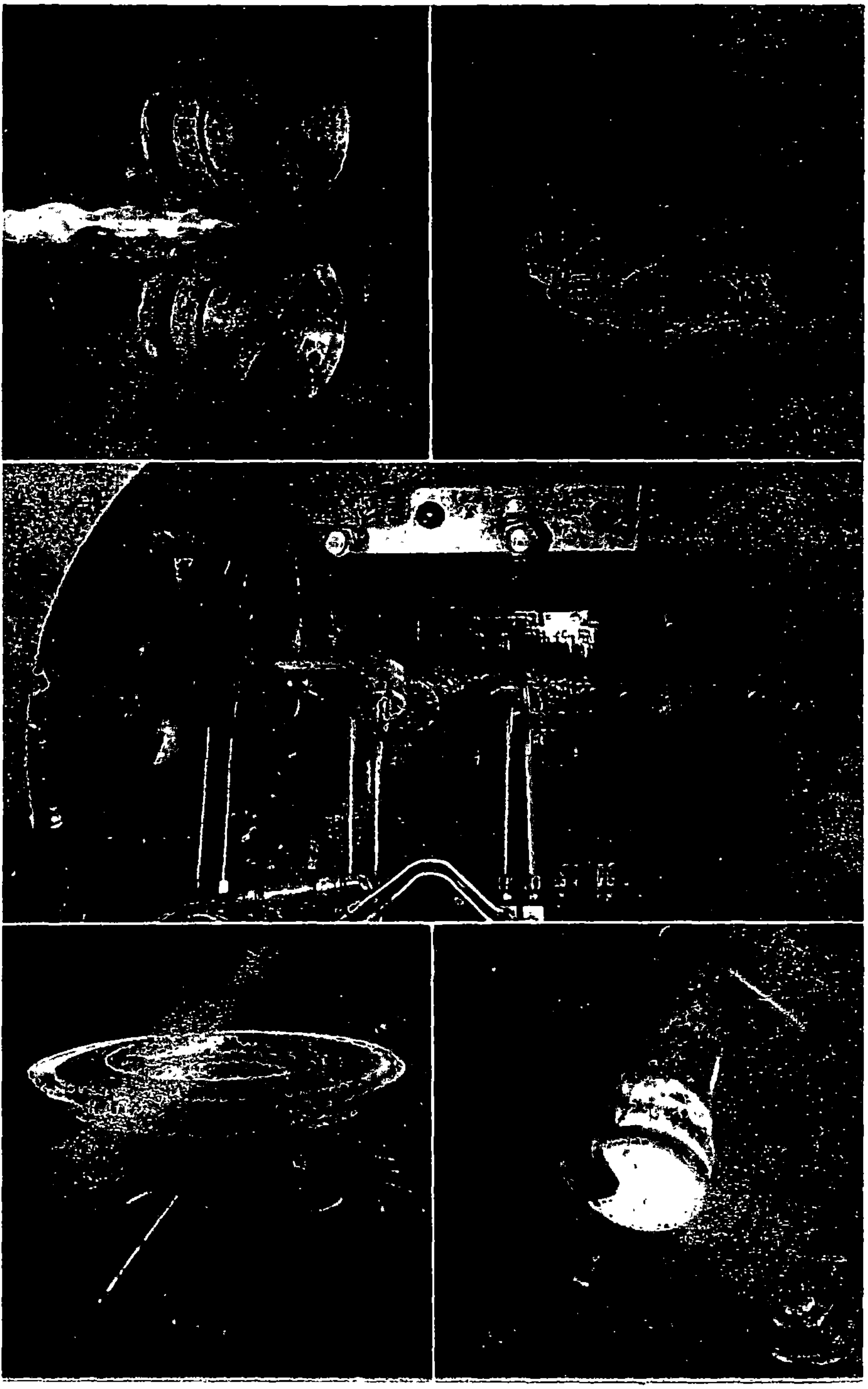
MAXIPRES® GOES AUTOMATIC!

COLD FORMER TRANSFER AUTOMATES FORGING PRESS! Adapted to the Maxipres, this production-proved transfer mechanism now gives you rugged, dependable automatic press forging.

The transfer, mounted right on the front of the press, *swings out of the way in less than thirty seconds* for easy access to the dies and transfer. Each transfer station quickly changes from a straight-across movement between dies to a turnover movement, depending on job requirements. The automated Maxipres can be equipped with air ejection for long-stemmed extrusions. Combine all this with the obvious advantages of automatic forging – Mass Production, Superior Quality, Maximum Machine Usage, Reduced Labor Cost – and you have the savings that only automatic forging can give you.

Can your forgings be made automatically?

Let us help you investigate the application of Automatic Maxipresses to your forging jobs. No obligation.



high-velocity forging

—new application of HERF

By Daniel B. Dallas
Associate Editor

First designed for forging the exotics, HERF presses are now moving into industry as a complement to conventional forging equipment. Using compressed gas as a source of energy and substituting high ram velocity for ram mass, they are—on a pound-for-pound basis—the most powerful type of forging equipment around today.

HIGH-ENERGY-RATE forming, or HERF as it is referred to by many, includes four types of forming operations, all of which have little or no interrelationship other than a high rate of energy expenditure. The four are explosive forming, electrohydraulic forming, electromagnetic forming and pneumatic-mechanical forming. Each came into existence as a method by which Space-Age forming problems might be solved but all are finding a wide

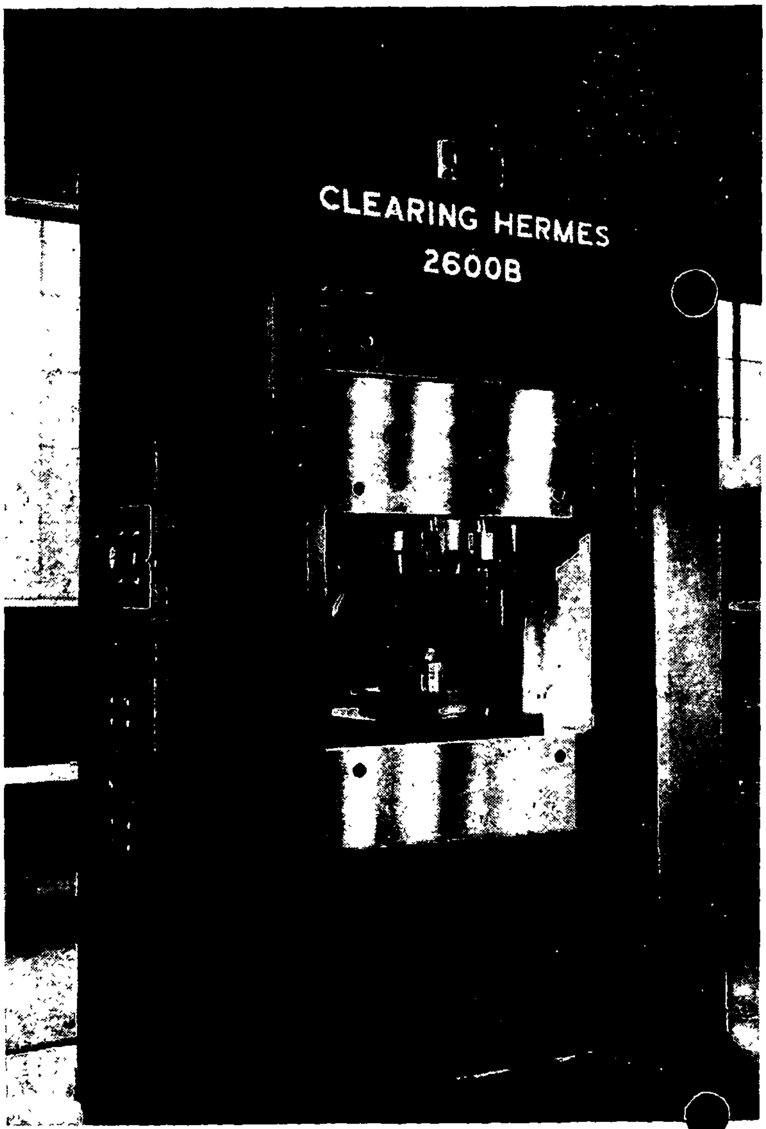
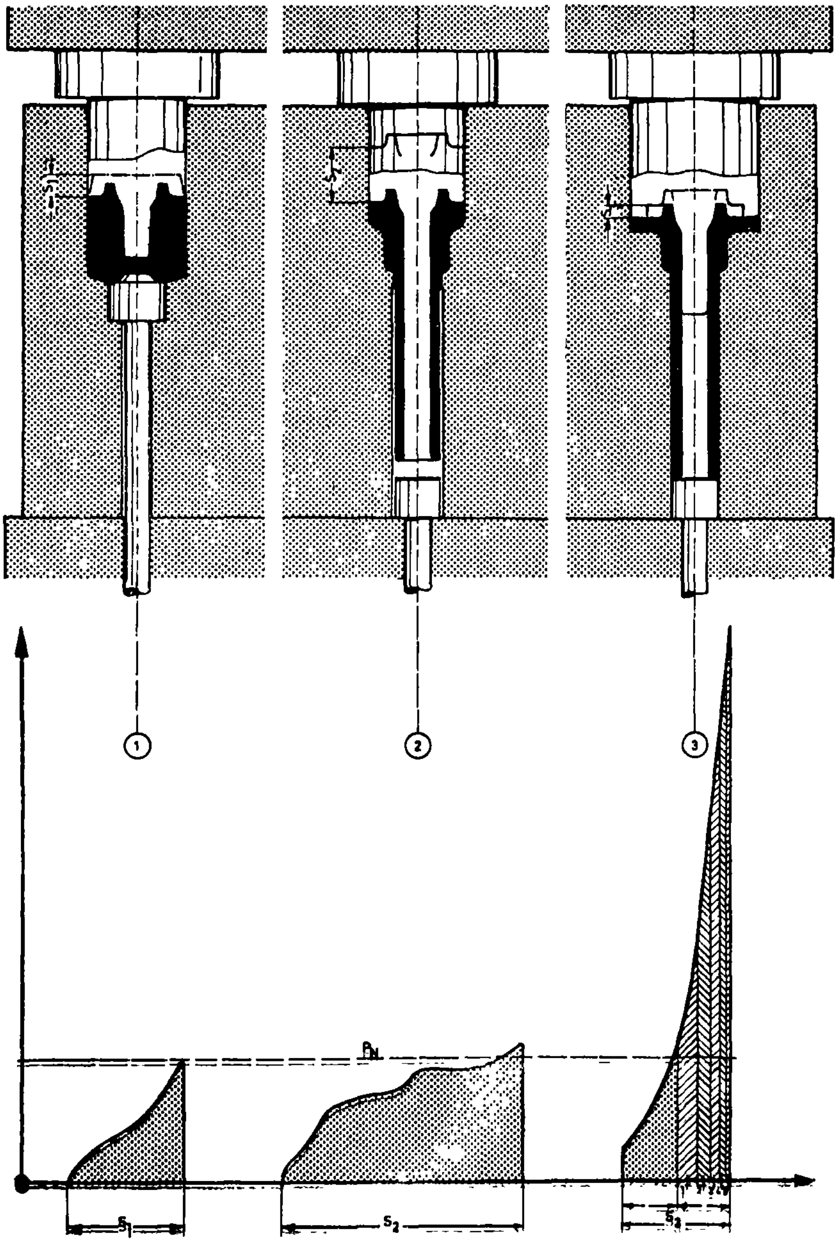


Fig. 1. Production setup for producing parts on Clearing Hermes pneumatic-mechanical forging press. Upper and lower platens move in this press, allowing workpiece to absorb full impact.

Ejemplo de trabajo: Fabricación de un eje tubular con brida (Fig. 1).



Secuencia de operaciones:

Partiendo de palanquilla en trozos, además del primer recalcado, son necesarias las siguientes operaciones:

Operación 1:

Prensado previo (Diagrama 1)

Operación 1 a:

Taladrado

Operación 2:

Prensado con fluencia

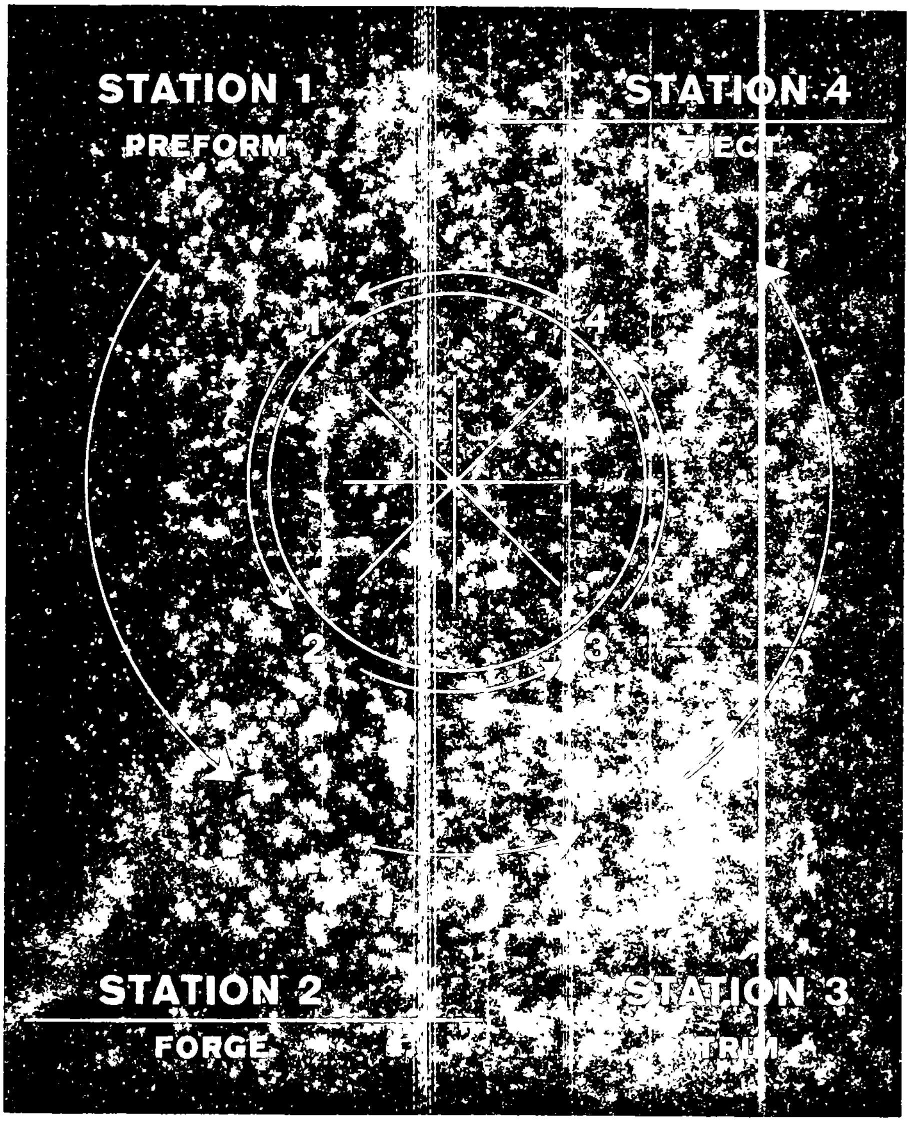
Operación 3:

Prensado terminado de la brida y martillado con objeto de obtener el diámetro mayor de la brida con contornos exactamente acuñados (Diagrama 3)

Este ejemplo demuestra que la prensa de forjar por presión e impacto SSP está en condiciones de suministrar en un tiempo muy corto, un trabajo de deformación ($A = P_m \times s$) muy grande a la pieza y que además, se alcanzan esfuerzos finales (Diagrama 3) que son un múltiplo de la fuerza nominal de la prensa. La reunión de las velocidades de deformación más favorables durante el prensado con la velocidad más conveniente del portaestampas o pilón en el momento del impacto, garantiza un rendimiento de forjado máximo.

Autoforging—From Molten Metal

A new metalworking process, known as Autoforging, promises to make it possible to produce at lower costs and with better quality many parts now made by conventional forging or casting techniques. The process, developed by TMW Division, North American Rockwell Corporation, produces finished parts in an automatic four station process: preform, forge, trim, and eject.



The four-station Autoforge process. A preform, produced by pouring molten metal into a water-cooled mold, is transferred to the forging station for final forming. After being trimmed, the finished part is ejected from the machine.

Preforming: At the preform station, molten metal is poured into a water-cooled copper mold. Either an open mold—a mold with a bottom section—or a closed mold—a mold with separate top and bottom sections—can be used, depending upon product design. Appendages to the preform, called runners, are also formed at the preform station, and in addition to feeding metal to the part act as supports to carry the preform through the machine for subsequent operations. After the preform cools enough to become self-supporting, it moves to an idle station for additional cooling.

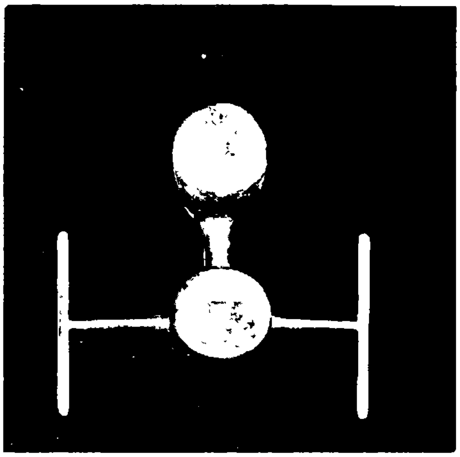
Forging: When sufficiently cooled, the preform is moved to the lower die of the forging station, where it is pressed to final shape by up to 200 tons of forging force at 2600 psi. Forging lubricant is automatically applied at this point.

Trimming and Ejecting: After the forging operation and cooling at a second idle station, the form is transferred to a 35 ton hydraulic press for the trimming operation. The finished parts are automatically ejected into a collection bin. The trimmed flash and runner skeleton are also ejected into a collection bin for return to the melting pot.

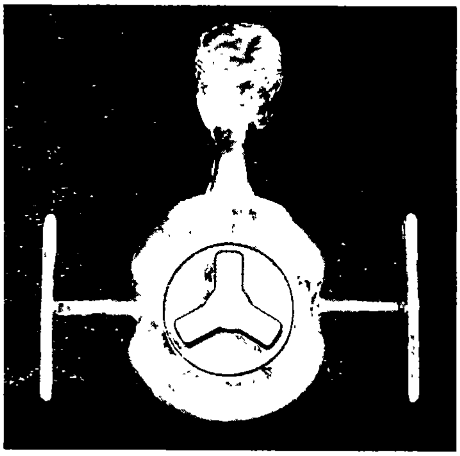
Process Economics: One of the major economic advantages of the Autoforge process is that the input material is in the form of scrap, instead of comparatively expensive forging rod that would normally be required.

Labor saving over conventional forging techniques is high, since, once molten material is introduced into the mold, no further material handling or operator intervention is required.

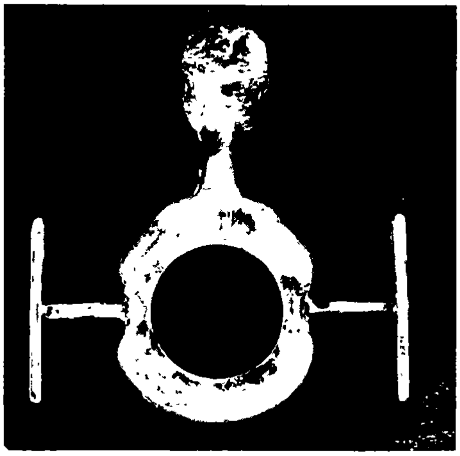
An additional saving lies in the fact that only one operator is required, in contrast to the two or four men required for conventional forging and trimming. The operating rates for both processes are similar



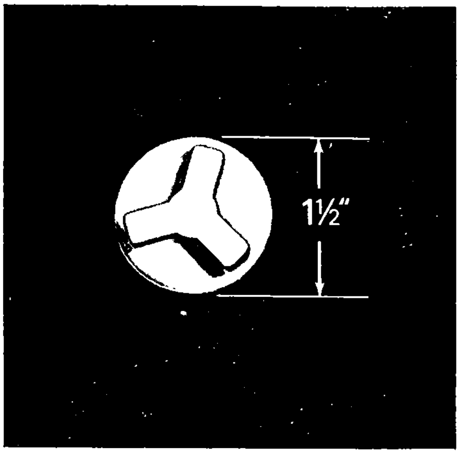
Preform



Forged



Skeleton



Parts

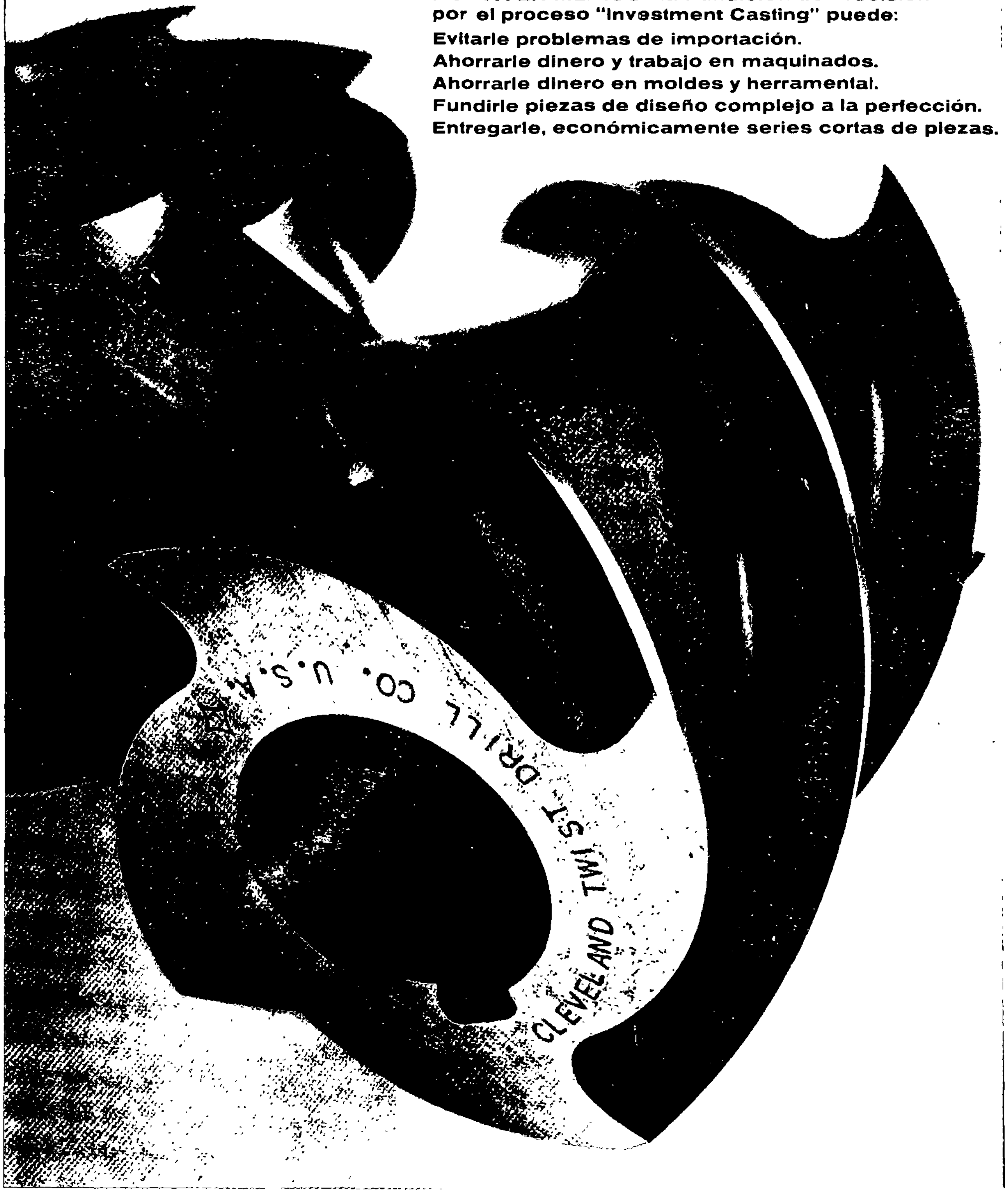
AutoForge

TMW Division
North American Rockwell

Reading, Pennsylvania 19603
Tel. 215-376-5701

Part	Pressure Cap
Material	C-1020 Steel
Cost Savings	17%
Part Weight	.219 lbs.
Yield	41% (wt. of part to wt. of total preform)
Production Rate	250 pieces/hr. 55 lbs./hr.
Notes	These parts were run on an experimental basis as part of a trial mold/die program.

FUNDICION DE PRECISION
EUTECTIC INVESTMENT CASTING
DE MEXICO, S.A.



Señor Industrial:

"NUEVA EN MEXICO" la Fundición de Precisión por el proceso "Investment Casting" puede:

Evitarle problemas de importación.
Ahorrarle dinero y trabajo en maquinados.
Ahorrarle dinero en moldes y herramental.
Fundirle piezas de diseño complejo a la perfección.
Entregarle, económicamente series cortas de piezas.

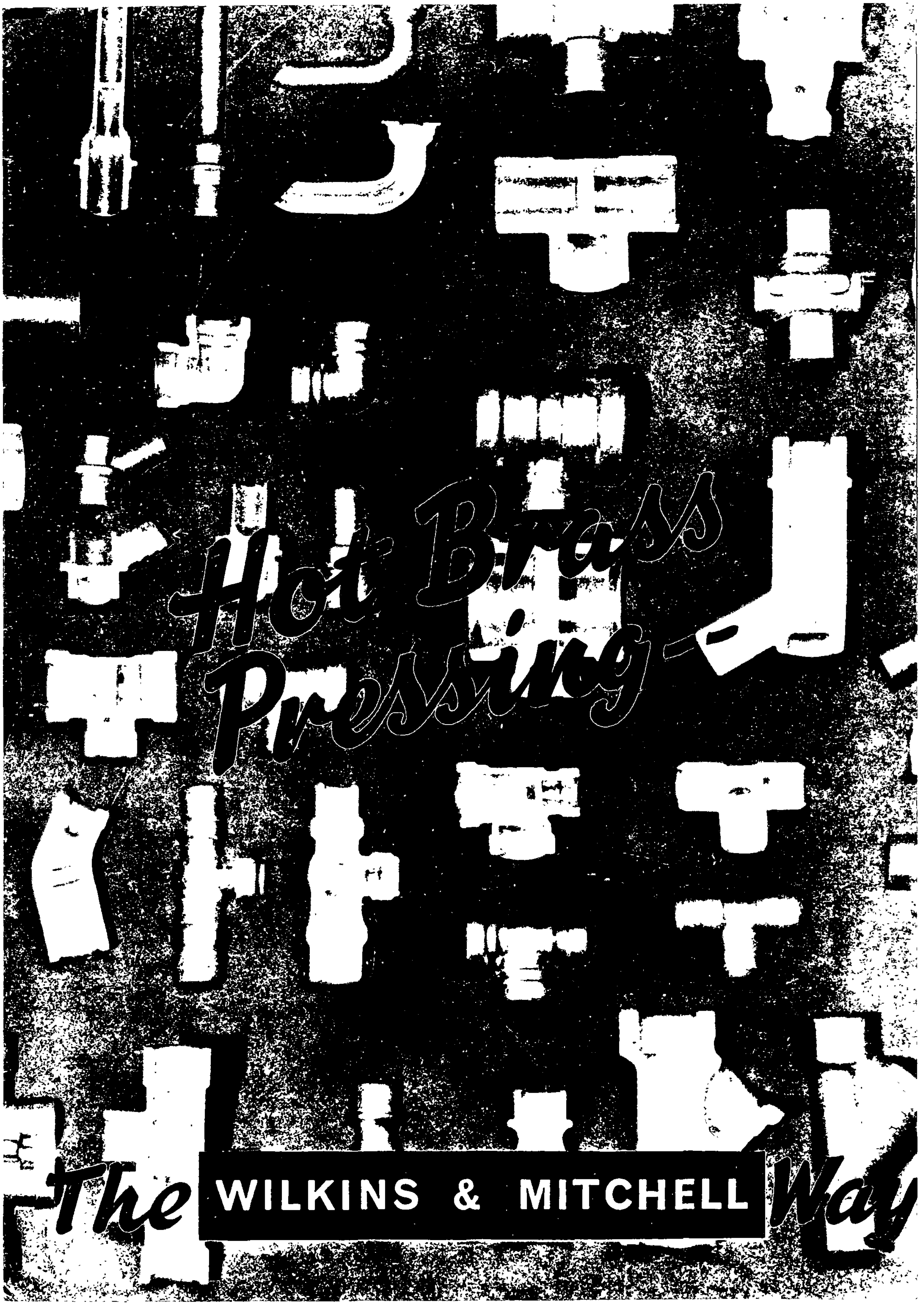
centro de educación continua
división de estudios superiores
facultad de ingeniería, unam

DISEÑO DE HERRAMENTAL

FORJA DE LATON EN CALIENTE

ING. ULRICH SCHARER SAUBERLI.

JUNIO, 1978.



Hot Brass Pressing

The WILKINS & MITCHELL Way

THE WILKINS & MITCHELL WAY OF HOT BRASS PRESSING IS BY THE USE OF PRESSES AND SUB-PRESSES FOR MULTIPLE CORING.

Brass forging has been practised in England for about 70 years and since 1918 cored components have been made on a limited scale. With the development of better die steels, Wilkins & Mitchell—pioneers in the power press field—saw the possibilities of cored pressings and in 1951 set out to develop a range of presses and sub-presses for this purpose. Accurate, high speed units were designed and built for the production of multi-cored brass pressings. Due regard was paid to easy loading of the hot billet and quick die change.

THE WILKINS & MITCHELL WAY IS A NEW WAY. NOTHING LIKE IT HAS BEEN DONE BEFORE.

Brass components produced on our presses and sub-presses are vastly superior to those made in any other way. When machined from the bar, cast, cold formed or produced by means of powder metallurgy, brass parts can never include all of the following seven advantages which we claim for our method :–

- HIGHER PRODUCTION RATES
- GREATER STRENGTH
- EASIER FORMATION OF COMPLEX SHAPES
- COMPLETE FREEDOM FROM POROSITY AND INCLUSIONS
- BETTER SURFACE FINISH
- DIMENSIONAL ACCURACY
- MORE MATERIAL SAVING

- HIGHER PRODUCTION RATES. 1,000 per hour is the production rate of components suitable for the Standard Tool and Die Holder, with one or two cores at 180° to each other, *e.g.* Jumpers.
  800 per hour for three core pressings using a Horizontal Sub-Press, *e.g.* Tees.
  300 per hour in cases of exceptional complexity and or when heavy loads are required in one direction, using a Vertical Sub-Press, *e.g.* Water Meter Bodies.

- GREATER STRENGTH. The forging action improves the mechanical properties of the metal and the closeness of the grain coupled with correct grain flow gives a high tensile strength throughout the component. The absence of porosity and inclusions enhances this.

- EASIER FORMATION OF COMPLEX SHAPES. The inherent ductility of brass at forging temperature makes possible the formation of complex shapes at one stroke of the press.

- COMPLETE FREEDOM FROM POROSITY AND INCLUSIONS. Forging action precludes porosity and the only inclusion is the billet used. No testing, therefore, is required for porosity and less time is spent on general inspection.

- GOOD SURFACE FINISH. No grinding or dressing is needed before polishing.

- DIMENSIONAL ACCURACY. Press and Sub-Press design and manufacture ensure that components with holes and cylindrical sections requiring tapping and screwing rarely require machining. Where machining is necessary, the profile accuracy and freedom from inclusions eases checking and extends tool life. Awkwardly shaped, unmachinable cores can be pressed accurately and without the need for dressing.

- MATERIAL SAVING. Five real reasons why The Wilkins & Mitchell Way saves material :—

  1. Large cores can be used due to the accuracy of the pressing.
  2. Little flash waste is encountered with the use of closed dies.
  3. No scrap components are produced due to porosity or inclusions
  4. Pressing accuracy minimises machining operations.
  5. A high tensile strength due to dense grain structure and correct grain flow means the pressing can be designed with thinner wall sections and therefore lighter in weight.

IN CLOSED DIE HOT PRESSING THE WILKINS & MITCHELL WAY, CORED COMPONENTS CAN BE PRODUCED OUT OF LESS METAL, IN LESS TIME AND AT LESS EXPENSE THAN IN ANY OTHER WAY.

THE WILKINS & MITCHELL HOT BRASS PRESS

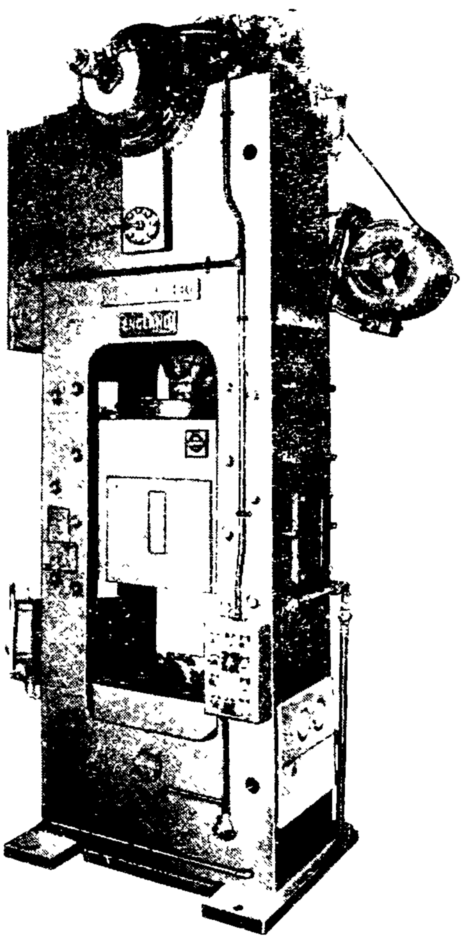
THIS PRESS, DEVELOPED SINCE 1951 IS DESIGNED AND MANUFACTURED SOLELY TO PRODUCE HOT BRASS PRESSINGS. ALTHOUGH IT IS BACKED BY 60 YEARS OF PRESS BUILDING EXPERIENCE, IT IS NOT AN ADAPTATION. PRESS CAPACITIES RANGE FROM 60 TO 250 TONS.

The following incorporated features we consider essential to long, high production runs:—

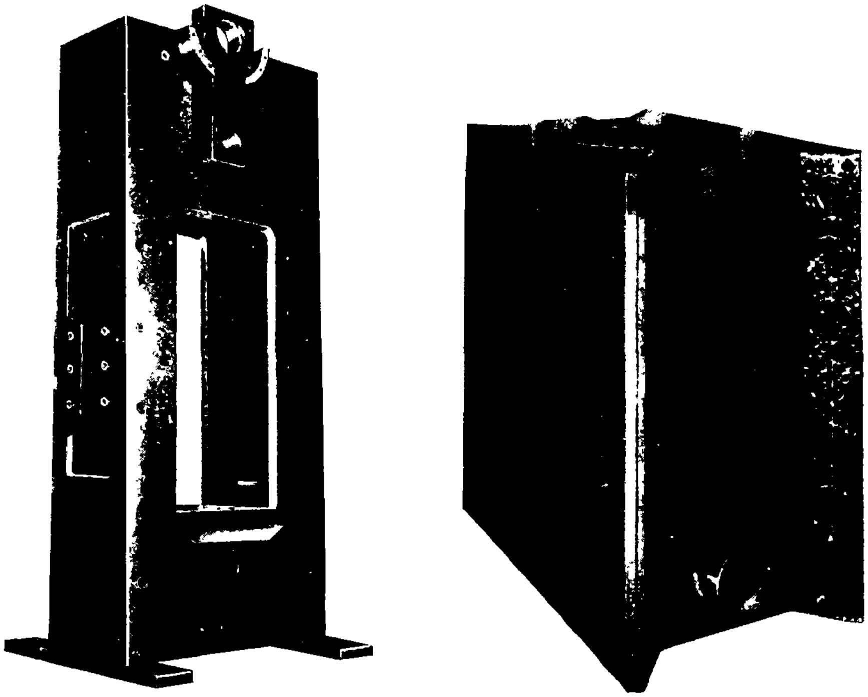
FRAME	All rolled steel, straight sided, welded in one piece. The 60 ton capacity press is open fronted.
SLIDE	Rolled steel, welded. Long slideways are inverted "Vee" type, so that as slide increases in size due to heat, gib clearances do not close.
SUSPENSION	Eccentric—no crank shafts.
BALANCE CYLINDERS	No gear backlash, no double stroking.
EJECTORS	Built in pneumatic in slide and bed. Mechanical in the 60 ton press slide.
LUBRICATION	Built in, centralised, forced feed grease.
CUSHION	Pneumatic bed cushion for sequence control of Sub-Presses.

Other features are:—

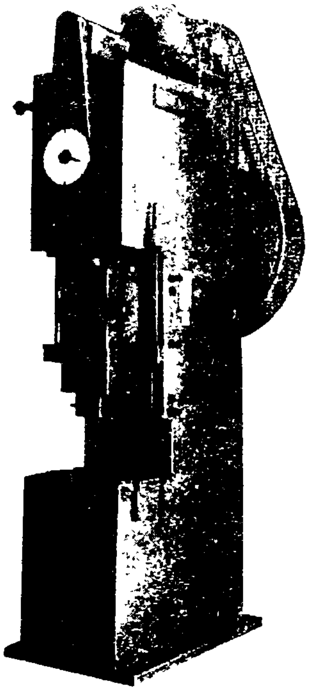
- Direct action, pneumatic, disc clutch and brake unit.
- Steel connecting rod.
- Motorised slide adjustment with visual indicator (when presses over 100 tons capacity).
- Single reduction double helical gearing.
- Setter's panel with push button and foot control.



100 tons capacity Hot Brass Press



Press frame and slide as used on 100, 200 and 250 tons capacity Presses.



60 ton capacity Press.

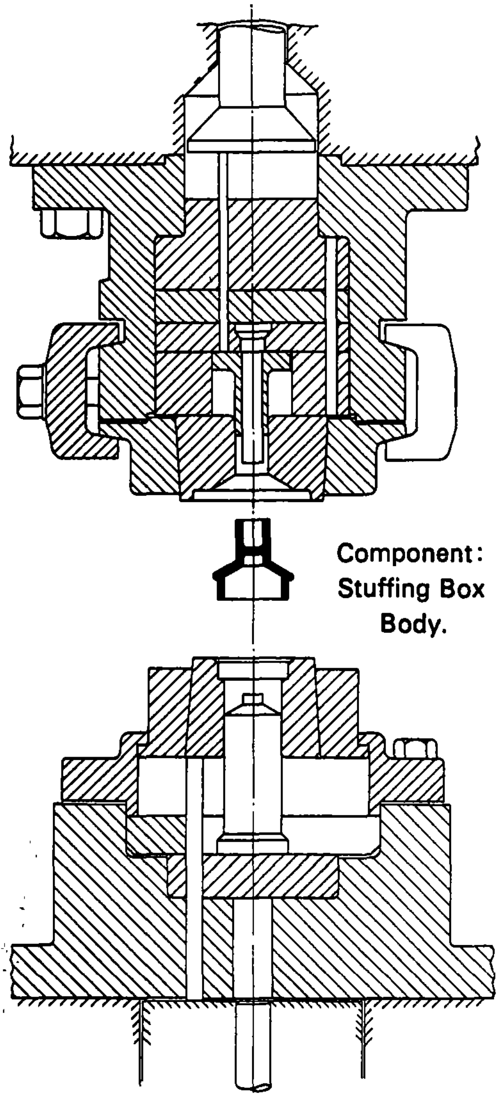
THE STANDARD TOOL & DIE HOLDER

FOR IN-LINE CORED PRESSINGS A STANDARD TOOL AND DIE HOLDER HAS BEEN DESIGNED. HIGH PRODUCTION RATES OF THE FOLLOWING AND SIMILAR COMPONENTS ARE BEING MADE:—UNION NUTS, TAIL PIPES, SINK WASTES, GRIDS, EASY CLEAN COVERS, SCREW DOWN HEADS, BONNETS, JUMPERS, GAS AND WATER UNION PARTS, GLAND RINGS, CAPSTANS, CRUTCHES AND WATER METER PARTS.

The hot billet is placed in the cavity of the bottom die. As the press ram descends the billet is enclosed between the top and bottom dies. No work has yet been done. As the dies continue to descend over the bottom punch, the metal is forced to fill the die cavity and produces the desired component, which is automatically ejected from either the top or bottom die.

The top die assembly shows the extractor pad or ring as the only moving part. The rest of the top die can be considered as a "solid" unit, as each part is located and is certain of correct alignment.

All parts of the bottom die assembly are held in place by a clamping ring which guides and limits the movement of the die itself, which is the only moving part. Clamping rings provide for three variations of movement. The taper register lines up the dies and the cushion pressure holds them together.



STANDARD TOOL
AND DIE HOLDER

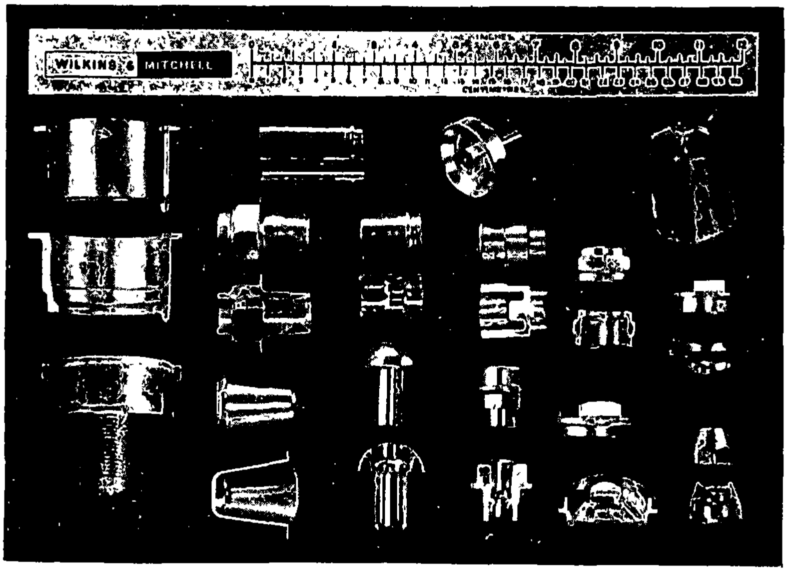
The "solid" top die design has the following advantages:—

Consistently accurate component production due to rigidity and absence of moving parts.

Small number of large parts to be handled hot during tool change.

Small number of parts to be made for other dies.

Products of Standard Tool and Die Holder.



THE VERTICAL SUB-PRESS, (Patent No. 883118)

THIS HAS BEEN DESIGNED FOR THE PRODUCTION OF MORE DIFFICULT CORED PRESSINGS WHICH REQUIRE HEAVY FORGING LOADS IN ONE DIRECTION. GATE VALVE BODIES, WATER METER BODIES, TRAP BODIES, LARGE ELBOWS AND TEE-PIECES ARE EXAMPLES.

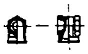
The unit comprises a base plate fastened to the press bolster, on which is the main punch; a centre body carrying four cone slides which are the die and punch holders, levers and an actuating cylinder; and a top cone fastened to the press ram.

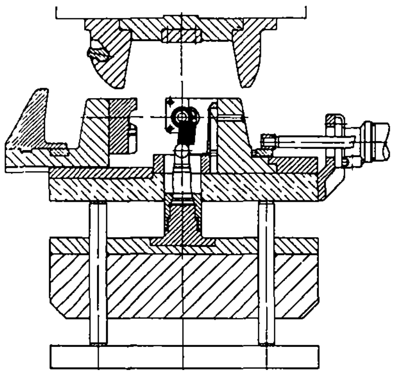
In the loading position the centre body is supported on pressure pins from the air cushion and the cone slides are wide apart. The main working punch is fixed to the base plate and points upwards through the centre body and into the billet cavity.

The hot billet is placed on the main punch and rests in the cavity of the right hand die.

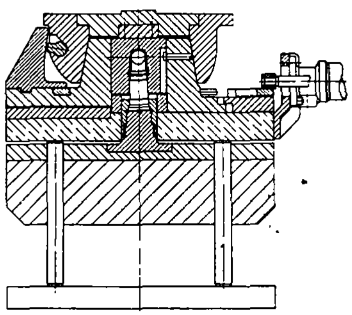
When the press foot pedal is operated the cone slides, with their punches, close round the hot billet and a cone slide limit switch puts the press into operation. The slides are locked together by the top cone and the centre body continues to descend against the cushion pressure over the main punch and the component is pressed. The press ram rises, the cone slides part and the component is ejected into the cavity for rapid removal.

Component:
Gate Valve Body.

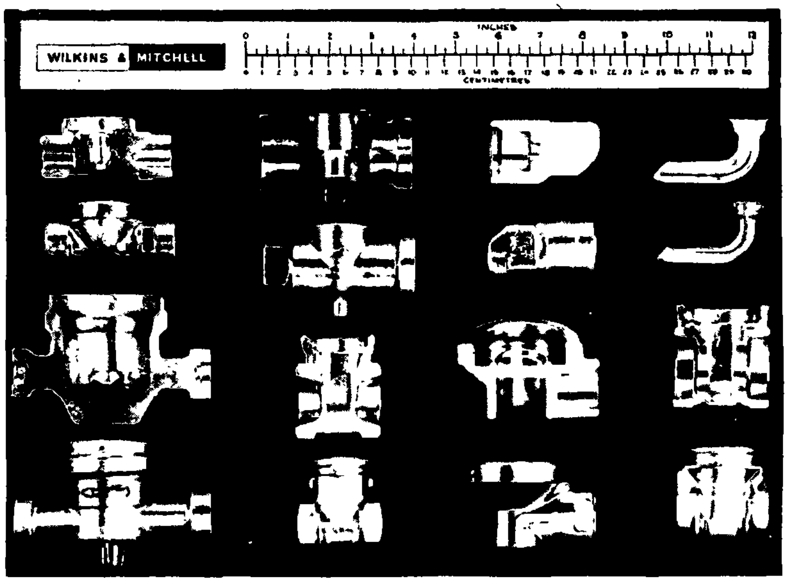




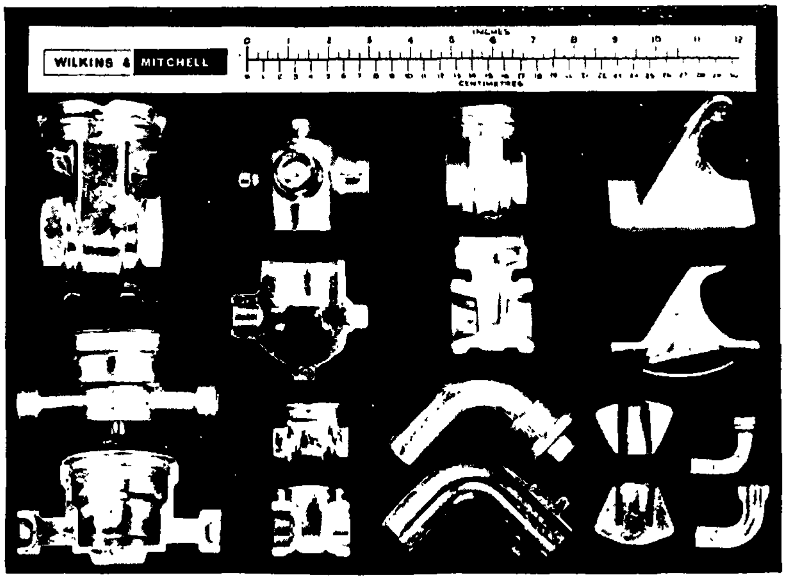
Open Position



Closed Position



Products of Vertical Sub-Press



Vertical Sub-Press in 250 ton Press

THE HORIZONTAL SUB-PRESS

THIS HAS BEEN DESIGNED FOR THE HIGH SPEED PRODUCTION OF CORED STAMPINGS WITH TWO OR MORE CORES AT 90° TO EACH OTHER. ELBOWS, TEE-PIECES, CROSSES, RADIATOR VALVE BODIES, GAS COCK BODIES, PILLAR AND BIB COCKS ARE EXAMPLES FOR THIS TOOL.

The unit comprises top and bottom plates bolted to the press ram and bed and a suspended central body carrying the punch stations. This central body rests on pressure pins from the bed air cushion. Dies are fixed to the top plate and the centre body; the latter presenting a horizontal cavity for the hot billet. As the press ram descends the die faces meet, enclosing the billet and the whole continues to move down against the cushion pressure. No work is done on the billet until the die faces meet. At this point three bell crank levers built into the centre body move the punches into the billet cavity, displacing the metal to produce the component.

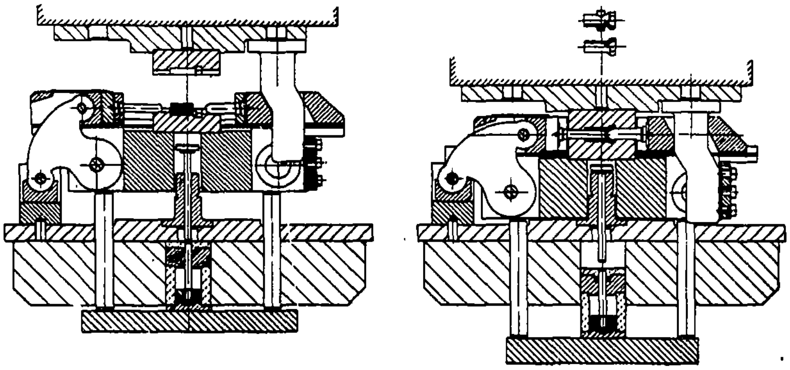
For some pressings two of these bell crank stations can be replaced by stations actuated from the press ram by means of cam pillars. These punches are fully in position before the die faces meet and do no work on the billet. They become stationary cores. Use of this type of punch is a unique feature of the Wilkins & Mitchell Way.

A special application giving coring at other than 90° can also be done on a cam pillar station.

In addition to the four side coring stations, two more can be fitted, one moving up through the bottom die and the other in the top die.

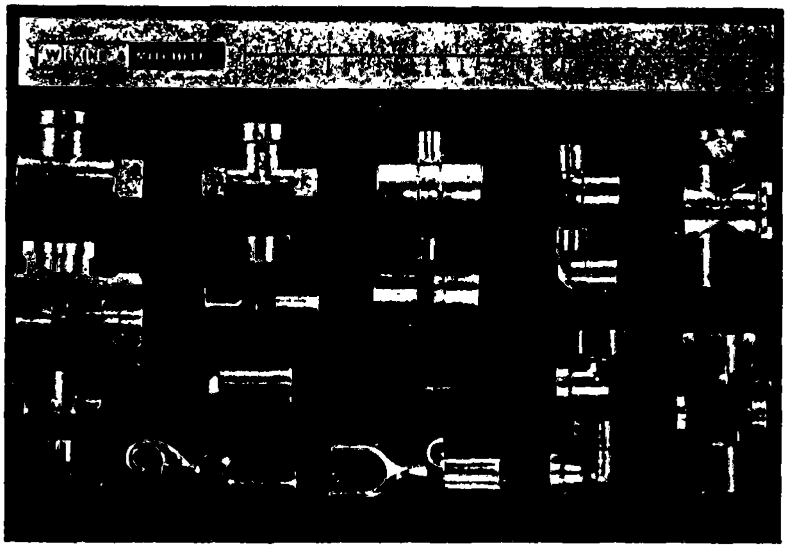
Automatic ejectors can be built into the dies.

Component:
Union Body



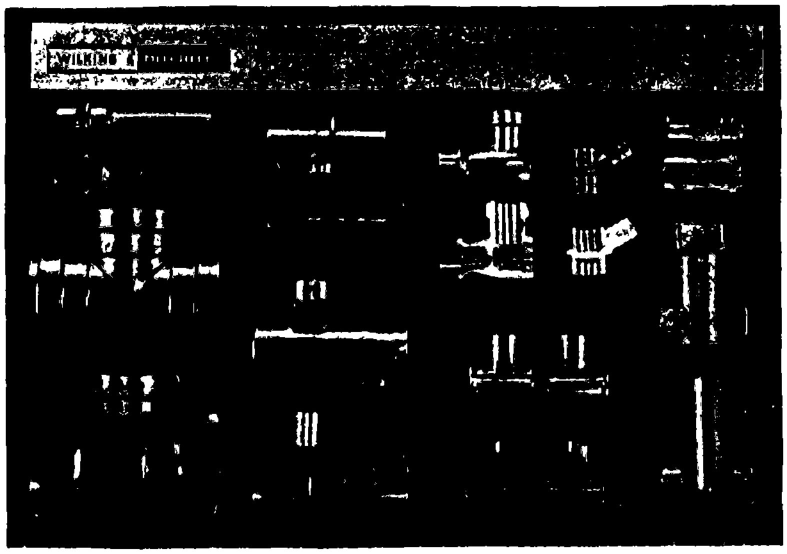
Open Position

Closed Position

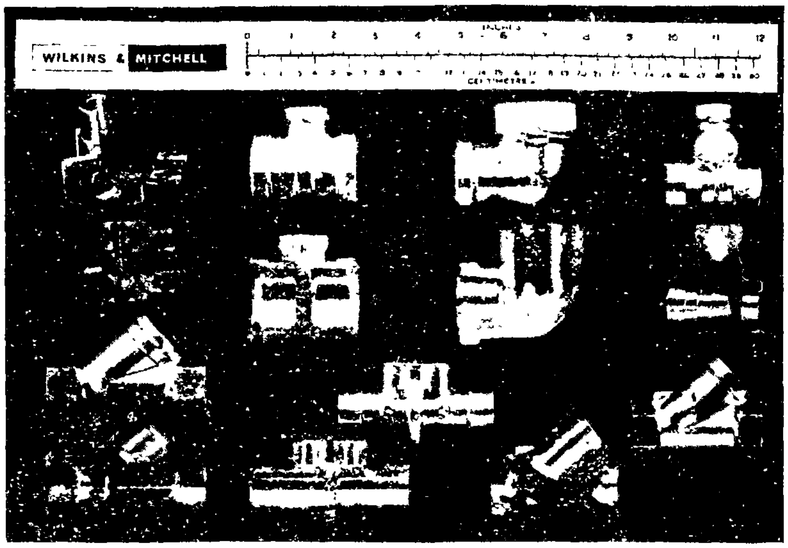


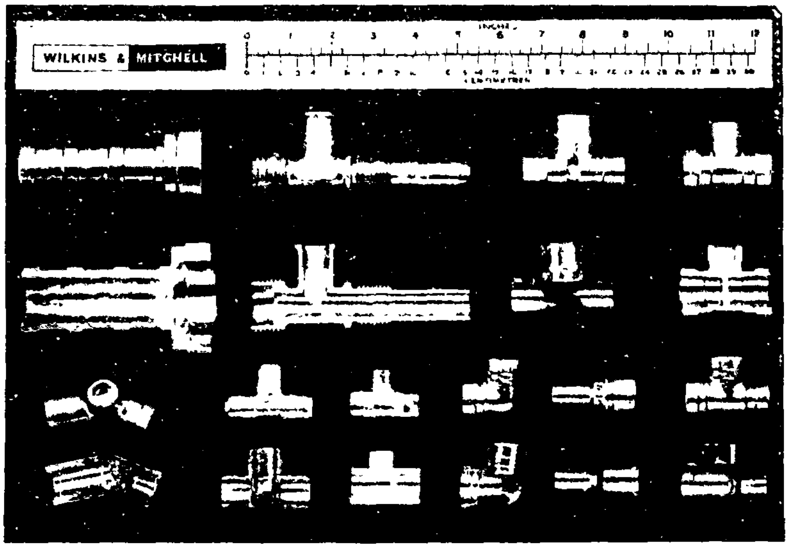
Products of Horizontal Sub-Press

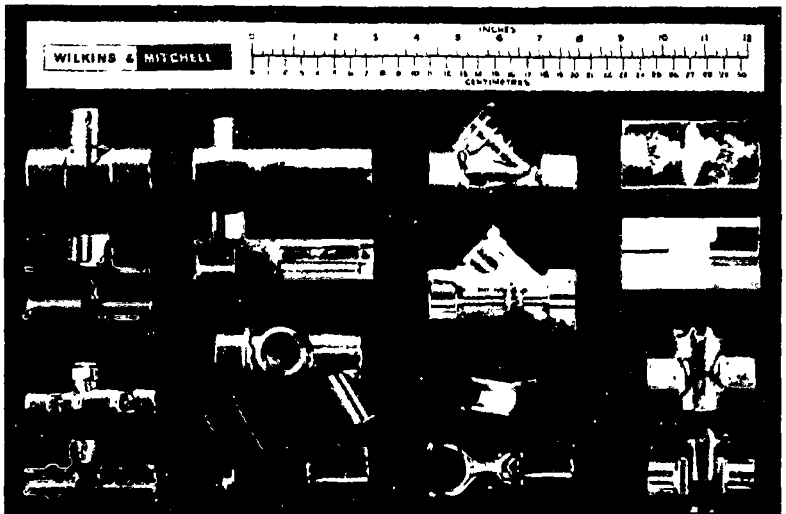
Tee pieces being produced on a Horizontal Sub-Press in a 100 Ton Hot Brass Press.



EXAMPLES SHOW THE GREAT VARIETY OF PRODUCTS FROM HORIZONTAL SUB-PRESSES WHEN USED WITH HOT BRASS PRESSES.







HAVE YOU A COMPONENT WHICH YOU THINK COULD BE HOT PRESSED? CONSIDERING THE GREAT NUMBER OF COMPONENTS, ONLY A FEW OF WHICH WE CAN SHOW IN THIS BOOK, YOU PROBABLY HAVE.

SEND US A DRAWING AND SAMPLE AND WE WILL BE PLEASED TO GIVE YOU OUR ADVICE. WE WILL TELL YOU THE SIZE OF THE PRESS REQUIRED, WHETHER YOU WOULD NEED A SUB-PRESS AND WHAT FORM THE TOOL WOULD TAKE.

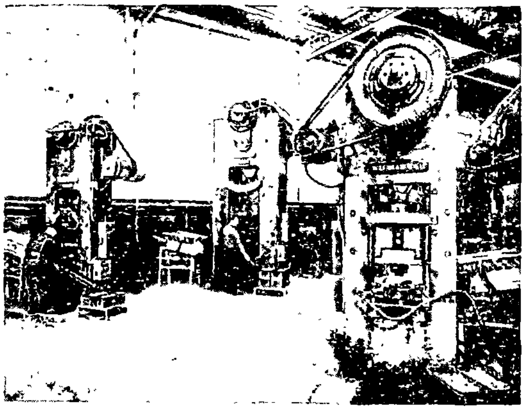
IF YOU WANT TOOL DRAWINGS WE WILL SUPPLY THEM—WE CAN ALSO SUPPLY THE TOOLS.

WE CAN TEST AND PROVE THE TOOLS.

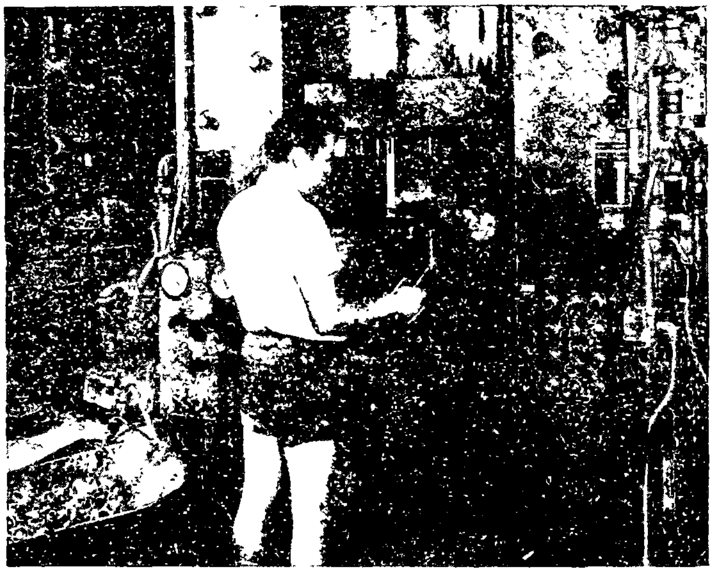
IF YOU WANT TO SEE THE TOOLS TESTED AND PROVED YOU CAN SEE COMPONENTS PRODUCED IN OUR DEMONSTRATION PRESS WHICH IS ALWAYS STANDING BY AT OUR DARLASTON WORKS.

LASTLY, BUT MOST IMPORTANT, WE HAVE A SECOND-TO-NONE WORLD-WIDE AFTER-SALES SERVICE FOR THE CARE OF OUR PRESSES, SUB-PRESSES AND TOOLS.

WHY NOT TRY THE WILKINS & MITCHELL WAY?

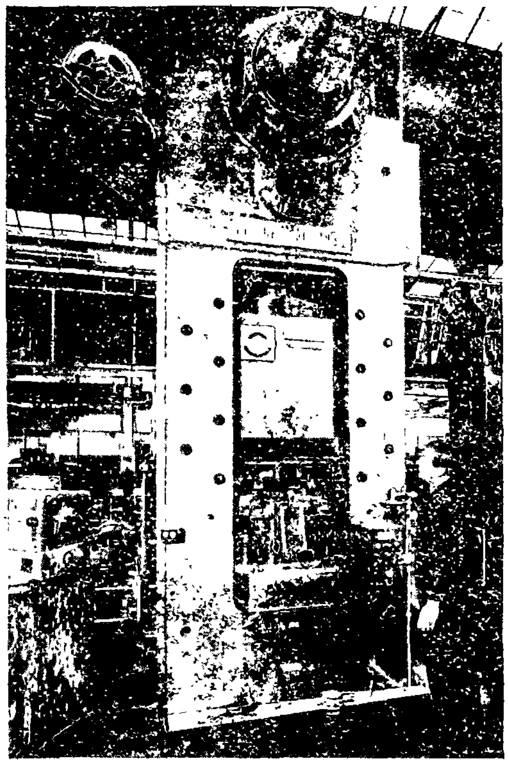


100 tons capacity Hot Brass Press fitted with Standard Tool and Die Holders



250 ton Press fitted with a Horizontal Sub-Press

250 ton Demonstration Press proving tools at our Darlaston Works



PRESS CODE		A19HB15	B24HB18	D30HB18	E30HB110
CAPACITY		60 long tons	100 long tons	200 long tons	250 long tons
STROKE		5 in 127 mm.	8 in. 203 mm	8 in. 203 mm.	10 in. 254 mm
STROKES per minute		70	60	60	48
SHUT HEIGHT, Adjustment up		11½ in. 292 mm.	16 in. 406 mm.	20 in 508 mm.	22 in. 559 mm
SLIDE ADJUSTMENT		3 in. 76 mm.	3 in. 76 mm.	4 in. 102 mm.	4 in 102 mm.
ADJUSTING MOTOR		Hand Operated	Hand Operated	3 h.p.—1420 r p m	3 h p.—1420 r.p m
SLIDE AREA	Right to Left Front to Back	9 in. 228 mm. 9 in 228 mm.	20 in. 508 mm. 17 in. 432 mm.	26 in. 660 mm. 24 in. 610 mm.	26 in 660 mm. 30 in. 762 mm
BOLSTER AREA	Right to Left Front to Back	19 in 482 mm. 15½ in. 394 mm	24 in 610 mm. 25 in. 635 mm.	30 in. 762 mm. 36 in. 914 mm.	30 in. 762 mm 36 in. 914 mm.
CUSHION LOAD at 100 lbs. per sq inch		3 long tons	11 long tons	30 long tons	30 long tons
CUSHION STROKE		2½ in 63 mm.	4 in. 102 mm.	4 in. 102 mm.	5 in 127 mm.
CUSHION AREA	Right to Left Front to Back	10 in. 254 mm. 10 in. 254 mm.	22¾ in. 578 mm. 17 in 432 mm.	26 in 660 mm. 26 in 660 mm.	26 in 660 mm. 26 in. 660 mm.
PRESS DRIVE MOTOR		7½ h p. — 1000 r.p.m.	10 h.p. — 1350 r p.m.	20 h.p — 1350 r p m.	35 h.p. — 1350 r.p m.
OVERALL HEIGHT		9 ft. 6 in 2895 mm.	12 ft. 2 in. 3708 mm.	14 ft. 8 in 4470 mm.	15 ft. 1 in. 4597 mm.
OVERALL WIDTH	Right to Left	3 ft. 0 in 914 mm.	6 ft. 4 in. 1930 mm.	8 ft. 6 in. 2591 mm	9 ft. 1 in. 2769 mm.
OVERALL DEPTH	Front to Back	5 ft. 0 in. 1524 mm.	5 ft. 6 in. 1676 mm.	7 ft 0 in. 2134 mm	7 ft. 10 in. 2388 mm.

WILKINS & MITCHELL (POWER PRESSES) LIMITED

Head Office & Works
THE GREEN, DARLASTON, WEDNESBURY, WEST MIDLANDS, WS10 8AN,
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división de estudios superiores
facultad de ingeniería, unam

DISEÑO DE HERRAMENTAL

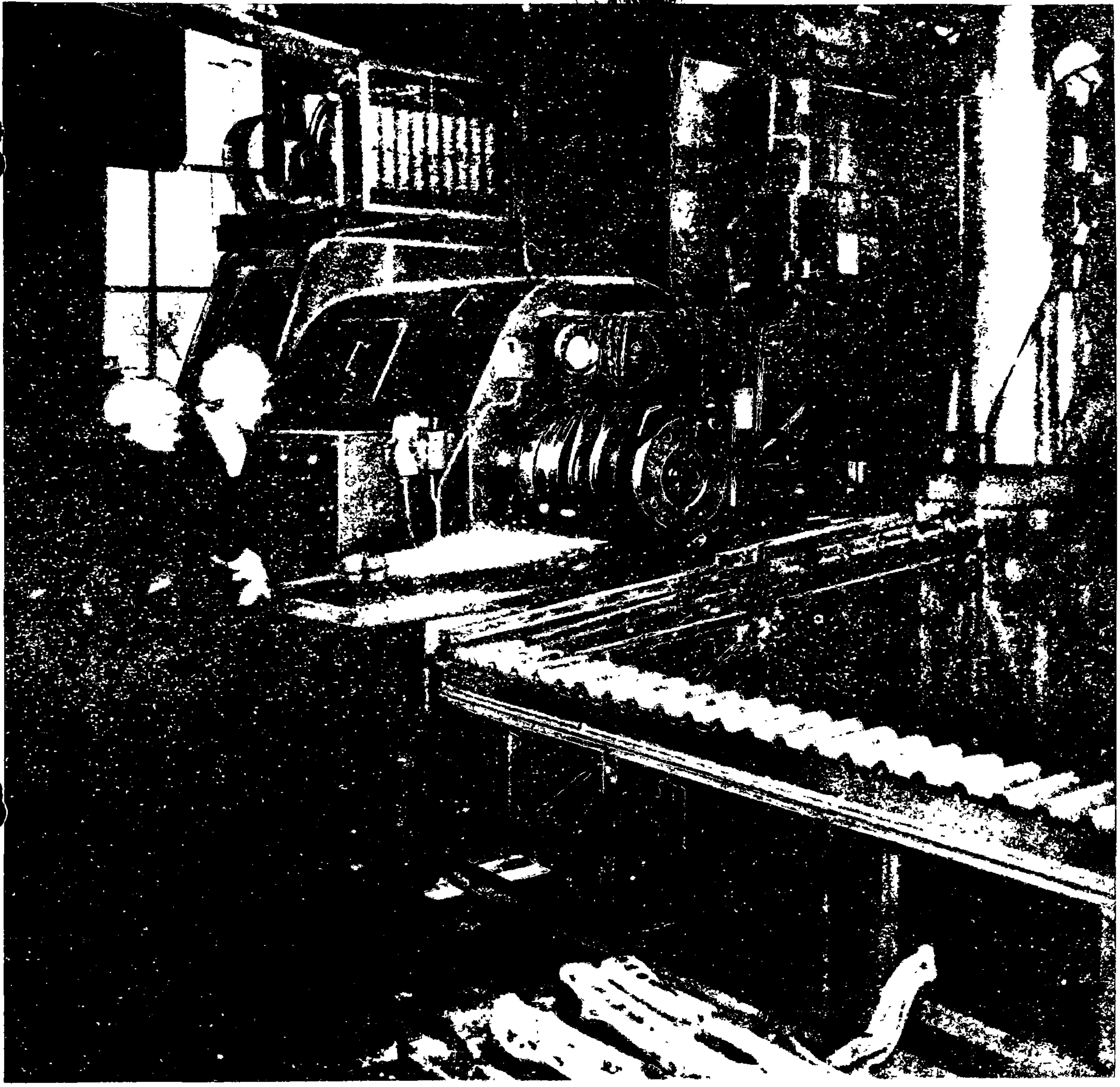
ROLES P / FORJA

ING. ULRICH SCHARER SAUBERLI.

JUNIO, 1978.

WILKINS & MITCHELL

cantilever and double bearing forging rolls
capacities 1.50 square inches upwards



◀ RM Series ▶

Wilkins & Mitchell design and build two types of Forging Rolls for the Forging Industry. The Rollmaster cantilever type is called the RM series and has overhung rolls for the rapid production of pre-formed uses for forging presses and hammers.

The other called Double Bearing Forging Rolls, DBFR series, has long rolls contained between widely spread bearings and will produce a longer use. An overhung roll is also provided.

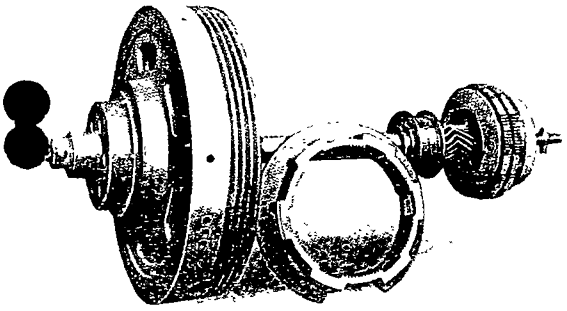
RM series have sizes:- RM 8, for rolling 1½″ square bars — RM 10, 2¼″ square — RM 12, 3″ square — RM 15, 4″ square — RM 20, 5″ square.

DBFR series have sizes:- DBFR 2, for rolling 2⅛″ square bars — DBFR 3, 3″ square — DBFR 4, 4″ square — DBFR 5, 5″ square.

An advisory service for the design and supply of rolls is in operation.

Wilkins & Mitchell Forging Rolls are backed by a world-wide after-sales service. This is your production guarantee.

Both RM & DBFR frames are of fabricated rolled steel. RM frames have lifting lugs for portability All gears are precision generated and RM gears are in an oilbath Both rolls incorporate a Wilkins & Mitchell direct-acting disc type clutch and brake unit Lubrication of RM series is by oil pump and DBFR by an automatic grease pump. Both have electric controls, cycling, continuous running, inching and emergency stop. Clutch dual sensing solenoid valves are fitted as an anti-repeat safety feature.

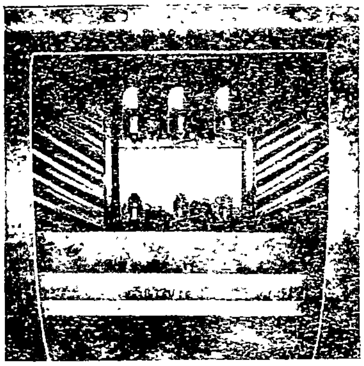


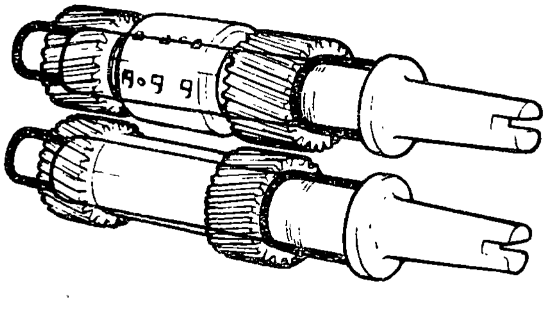
PNEUMATIC DISC CLUTCH

RM & DBFR Rolls The clutch and brake are multi-plate and direct-acting Friction discs of the clutch are at the flywheel end – those of the brake are at the opposite end The clutch and brake are directly coupled by a rod which passes through the first motion shaft Brake application is by multiple springs

ROLL MATCHING

A view of the RM top roll shaft pinions is illustrated Between the pinions is the nut for relative angular adjustment of the rolls Mis-matching of the two roll impressions can be corrected This feature is exclusive to Wilkins & Mitchell rolls



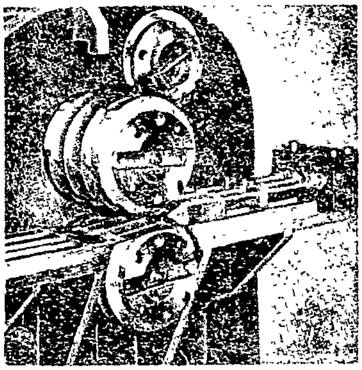


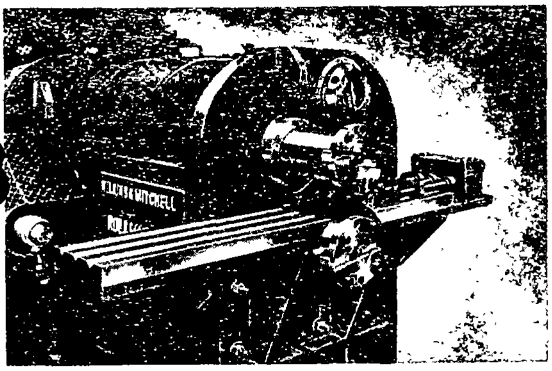
ROLL SHAFTS

RM Roll Shafts have large well spaced bearings which reduce cantilever effects to a minimum for the continuous production of accurate uses DBFR shafts are of generous size to support their multiple roll segments between bearings

STOCK SIZING

The RM Roll. Stock sizing is accurately effected by a graduated roll adjusting station placed above the top roll Adjustable back stops can also be seen which make provision for quick setting to give the needed rolling length These stops are arranged to start the rolls automatically when the stock touches them Stops are normally provided for a three pass roll



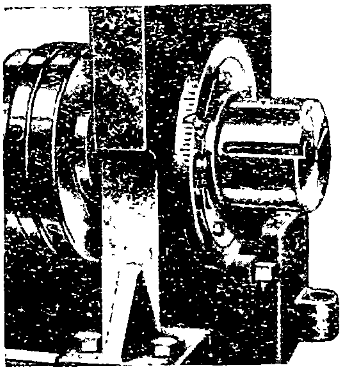


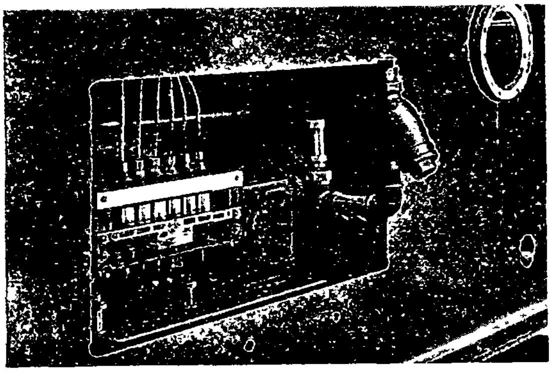
ROLL CHANGING

The operating end of the RM roll shaft illustrated is tapered and carries a split collet for securing the rolls Roll torque is transmitted by keys which engage the shaft, collet and roll. DBFR roll segments butt onto full length keys on the shafts and are interlocked and clamped endwise

STOCK SIZING

The DBFR Roll In this type of roll, adjustment is similar to RM except that it occurs on the lower roll as illustrated Right and left hand bearings are eccentric and are geared together Adjustment is by ratchet with a positive lock



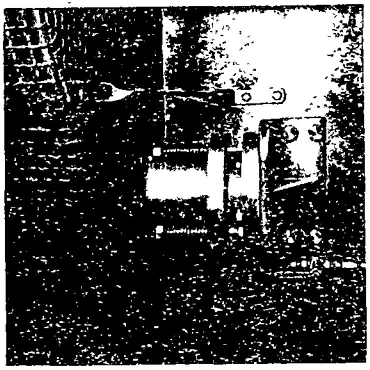


LUBRICATION

RM lubrication is a filtered forced feed oil system The visual feed indicator can be seen on the illustration Next to the pump unit is the transmission oil bath level indicator DBFR rolls have an automatic grease pump

PNEUMATIC FLYWHEEL BRAKE

A device for slowing and stopping the flywheel It is a safety measure and an aid to rapid roll changes



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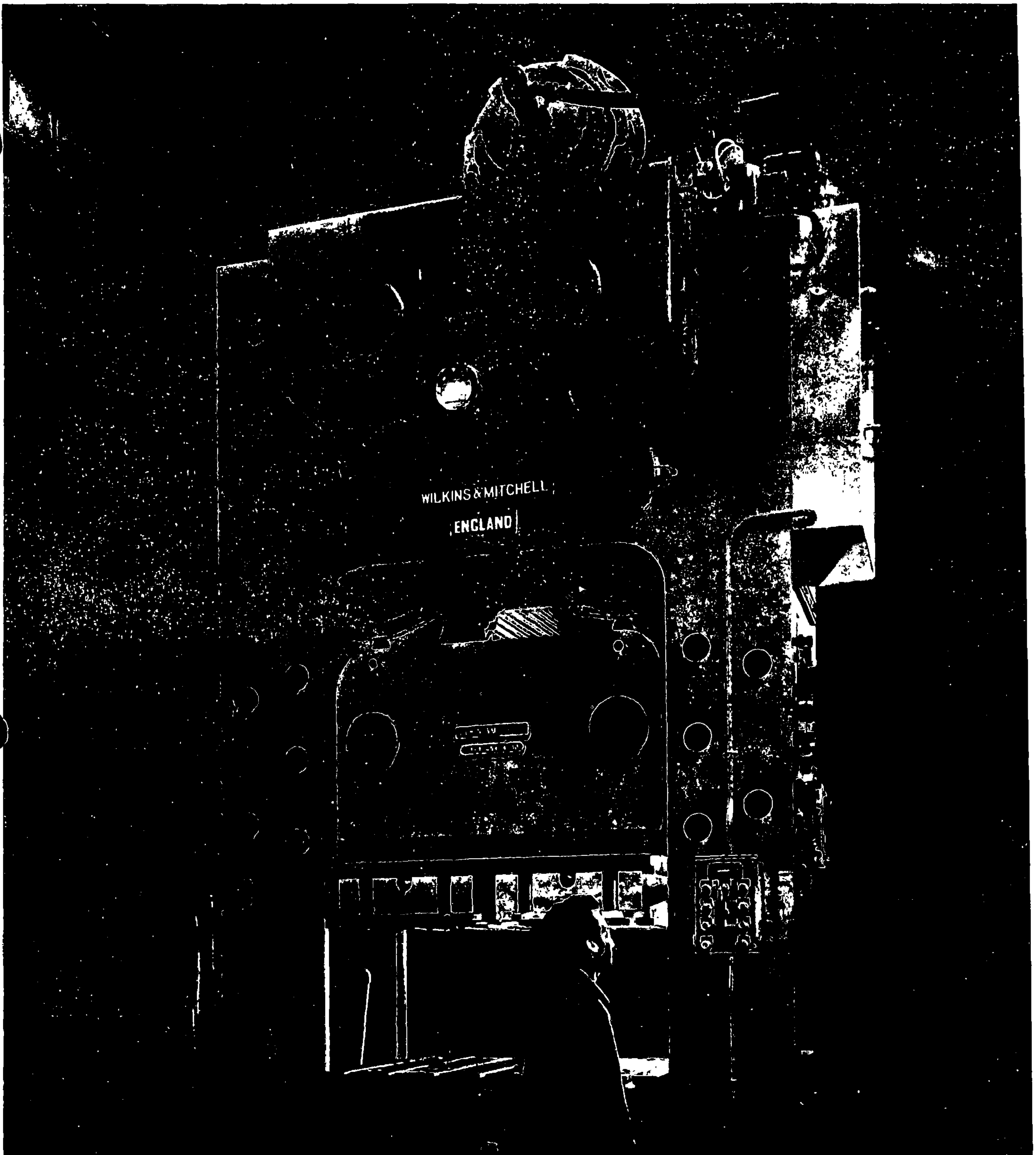
DISEÑO DE HERRAMENTAL

PRENSA DE FORJA P / REBABEAR Y CALIBRAR.

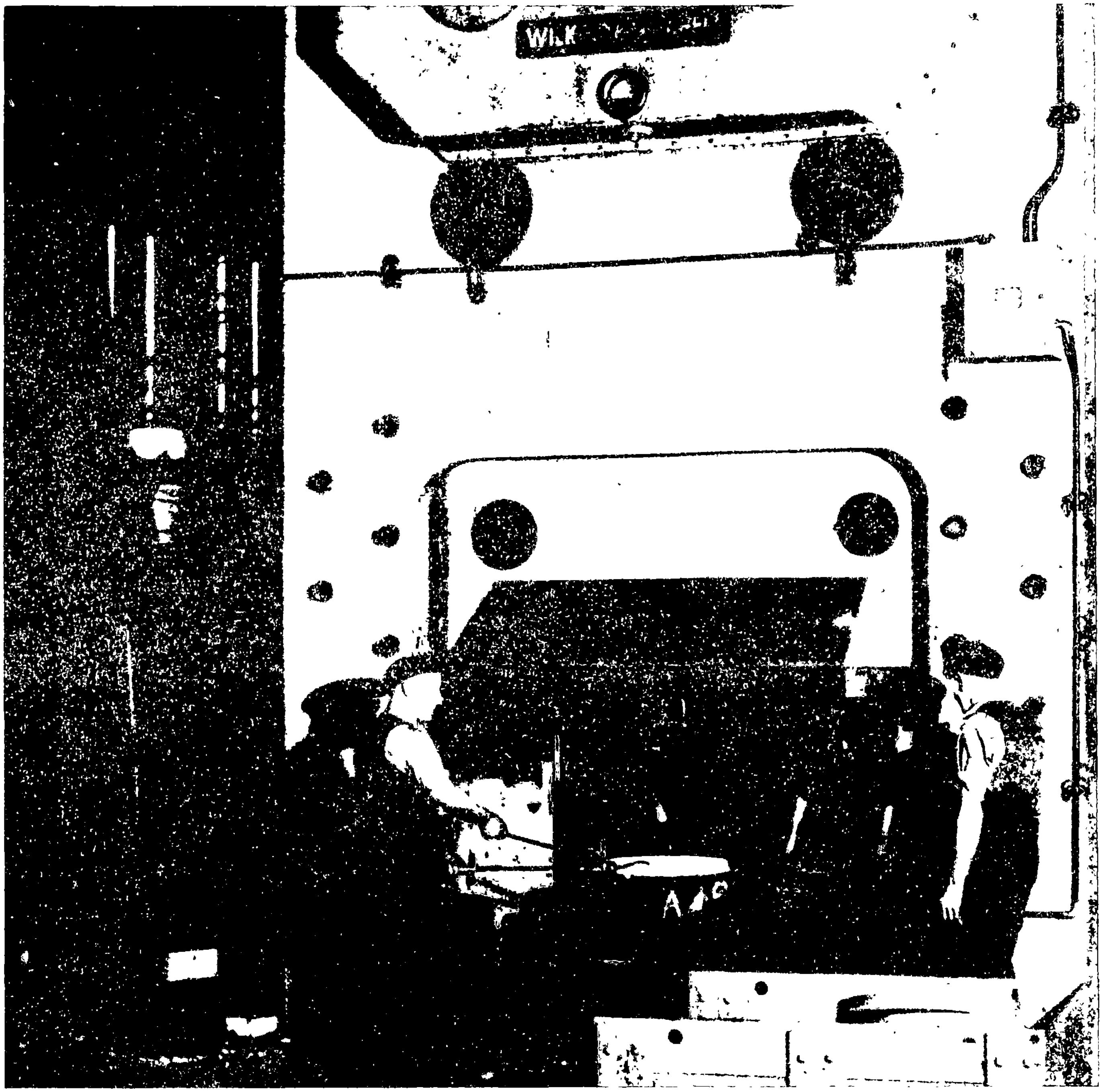
ING. ULRICH SCHARER SAUBERLI.

JUNIO, 1978.



WILKINS & MITCHELL

straight sided solid frame wide bed
CLIPPING & SETTING PRESSES
capacities 75 to 2500 tons



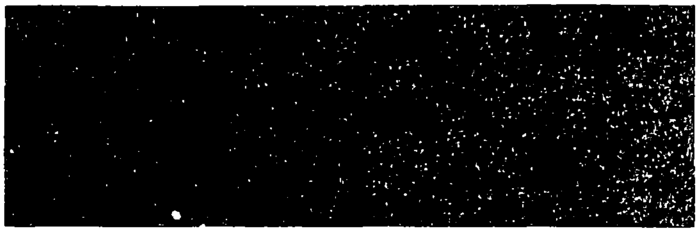
Left
preforming after cheesing

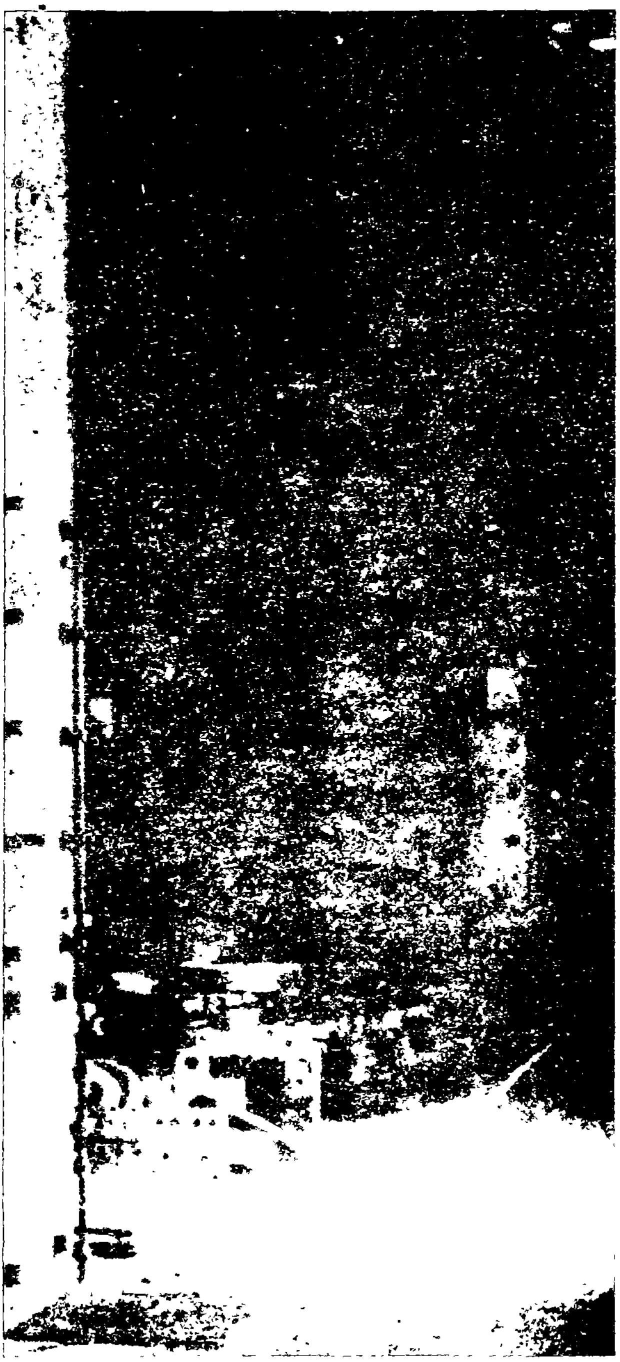
Right
clipping

Far left
cheesing

Far right
parallel piercing

Bending



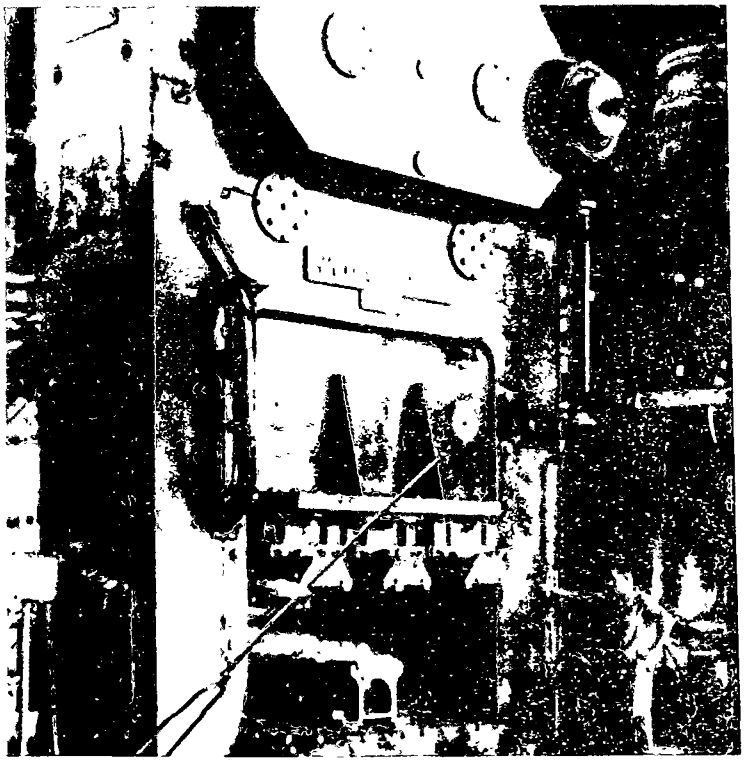


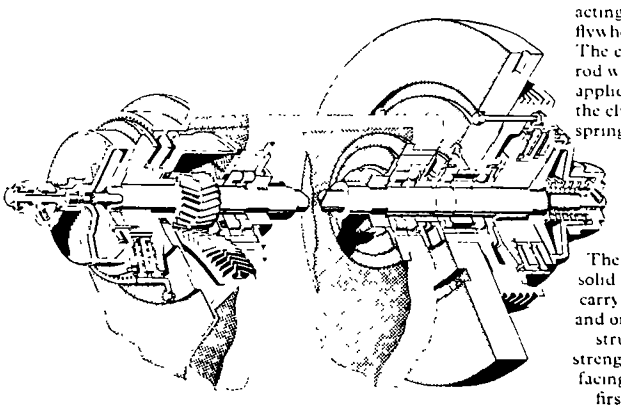
Wilkins and Mitchell pioneered the introduction of combined Clipping and Setting Presses for the exclusive use of the Forging Industry.

These presses are of straight sided, solid frame, wide bed construction. They daily perform all the operations needed before and after forging:- Clipping, Setting, Sizing, Coining, Piercing, Parallel Piercing, Cheesing and Bending Capacities range from 75 to 2,500 tons and are of one, two and four point suspension.

Main press parts are all steel welded fabrications. Lubrication is by pressurised grease from a pump at hand level. Electrics include two dual sensing valves for clutch control, setters panel and guarded footswitch

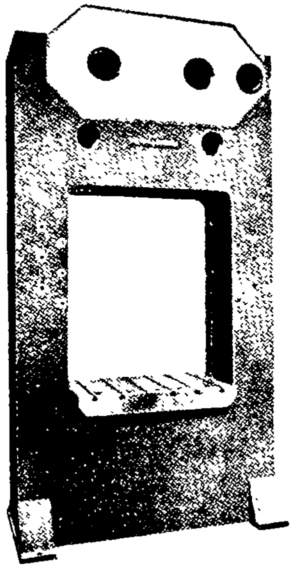
Wilkins and Mitchell world-wide after sales service is your production guarantee.





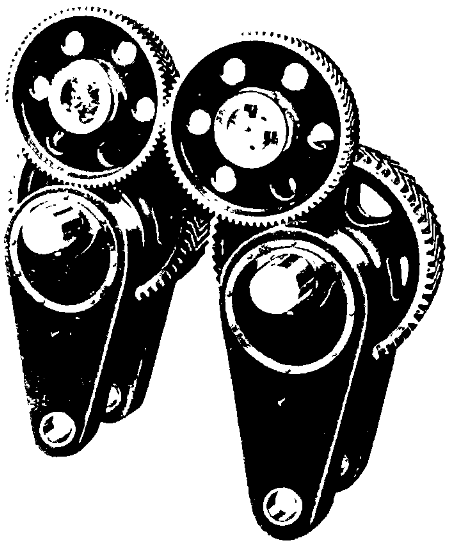
PNEUMATIC DISC CLUTCH

The Clutch and Brake are multi-plate and direct acting Friction discs of the clutch unit are at the flywheel end those of the brake at the opposite end The clutch and brake are directly coupled by a pull rod which passes through the first motion shaft Brake application is by multiple springs. The adjustment of the clutch and brake is done from the clutch end only, spring pressure remaining constant



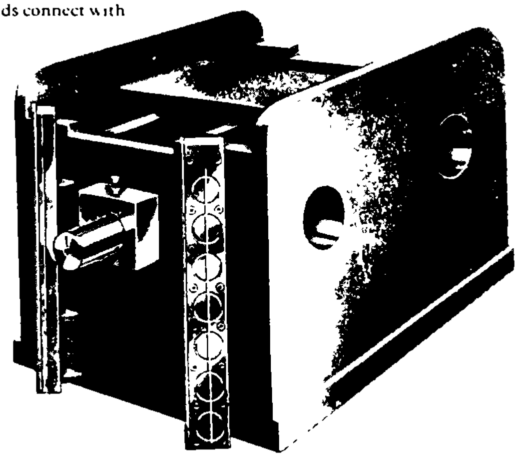
FRAME

The frame is of rolled steel plate The straight sided, solid construction is box section and there are no load carrying joints Two heavy uprights located one front and one back are spaced by cross plates and the whole structure is welded together into a unit giving great strength and rigidity At the top can be seen machined facings for the fitting of the oilbath, in which runs the first motion gears Below this are bores for the large diameter, forged steel, stationary mandrels to carry the eccentric gears The wide bolster is machined from steel slab and is shown "tee" slotted to customers requirements



TRANSMISSION

A vee belt drive from the motor to the flywheel transmits power to the clutch shaft which engages the intermediate gears. These are keyed to intermediate shafts, whose pinions engage the heavy eccentric wheels on which are suspended the connecting rods. All gears have double helical teeth and all pinions are cut solid on their shafts The clutch shaft is housed in ball and roller journals Intermediate shaft bearings and the bores of the eccentric wheels are lined with phosphor bronze The connecting rods also have phosphor bronze bearings both at their eccentric ends and where the little ends connect with stationary pins in the press slide

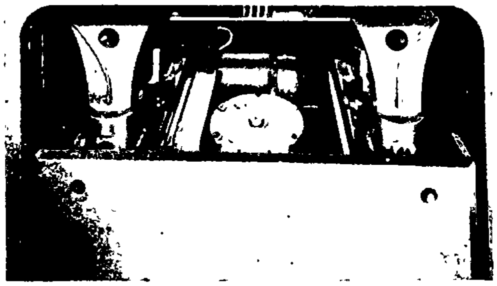


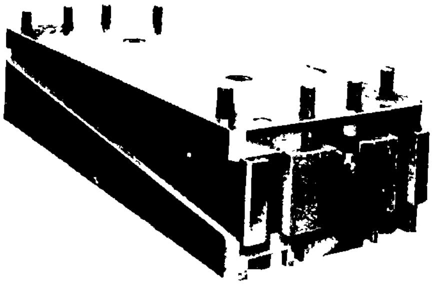
SLIDE

The slide is fabricated from rolled steel plate and carries a heavy base which is 'tee' slotted to customers' requirements. Forged steel gudgeon pins having permanent fixings are placed as near the slide corners as is constructionally possible and this, coupled with the opposed direction of the eccentrics, gives uniform pressure over the whole tool area By these means multiple tool set-ups are well provided for.

SCREW ADJUSTMENT

Where individual tool adjustment is not required, screw adjustment of the whole slide can be supplied as an optional extra.





WEDGE ADJUSTMENT

One or more wedges give a very necessary fine adjustment when tool setting Individual tool adjustment is made possible A steel wedge lies between a top plate, which is bolted to the press slide and a bottom plate which is "tee" slotted to take the tools An adjusting pin is on the front face of the wedge

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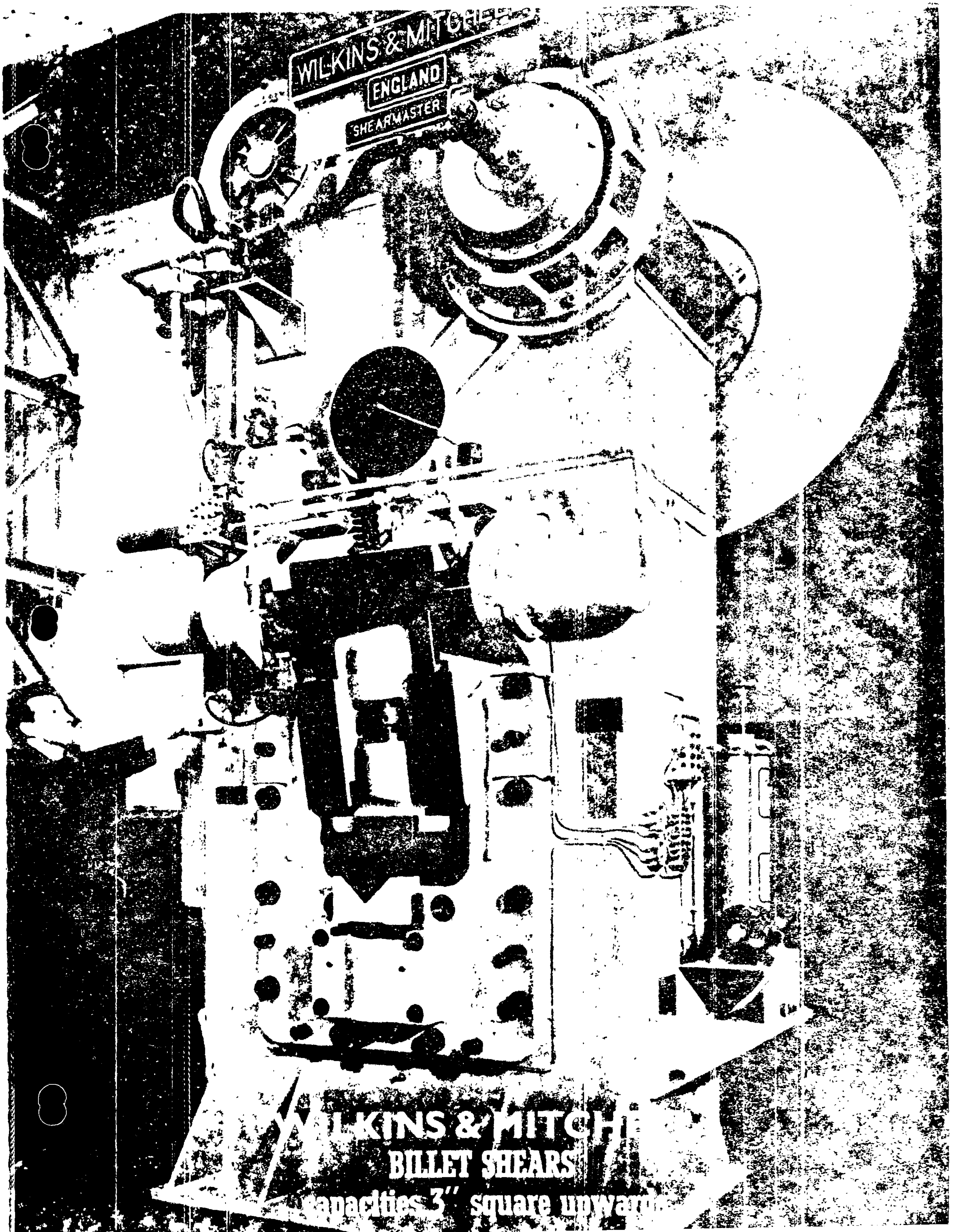
DISEÑO DE HERRAMENTAL

CIZALLA TOCHOS

ING. ULRICH SCHARER SAUBERLI.

JUNIO,1978.

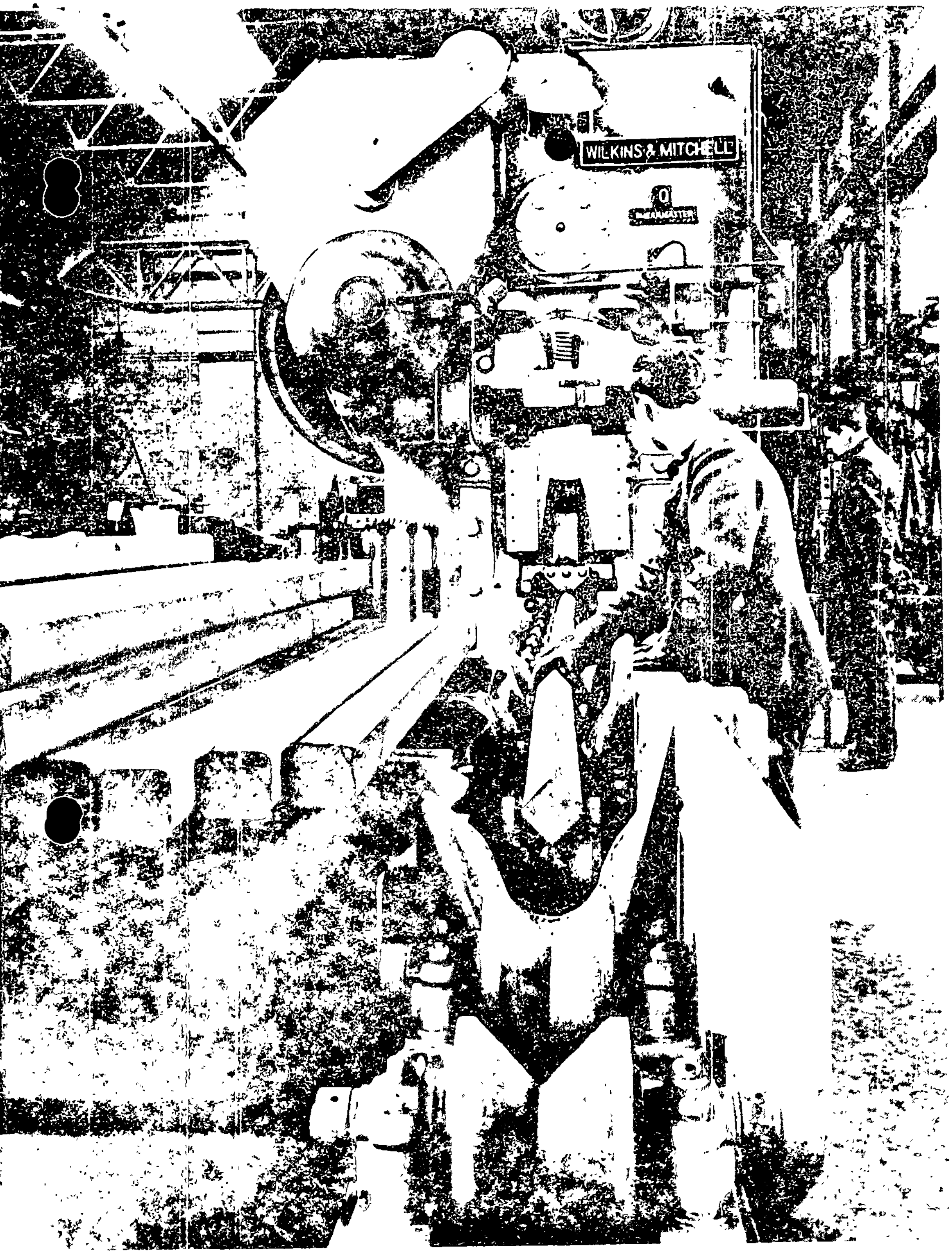
Palacio de Minería Calle de Tacuba 5, primer piso. México 1, D. F.



WILKINS & MITCHELL

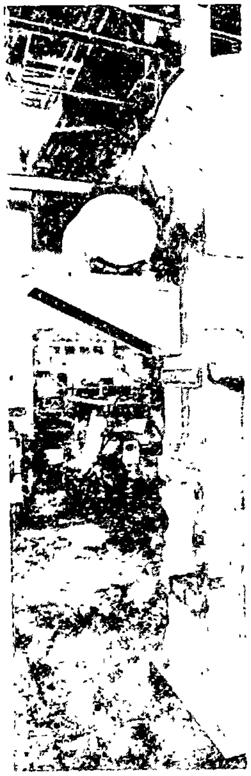
BILLET SHEARS

capacities 3" square upwards



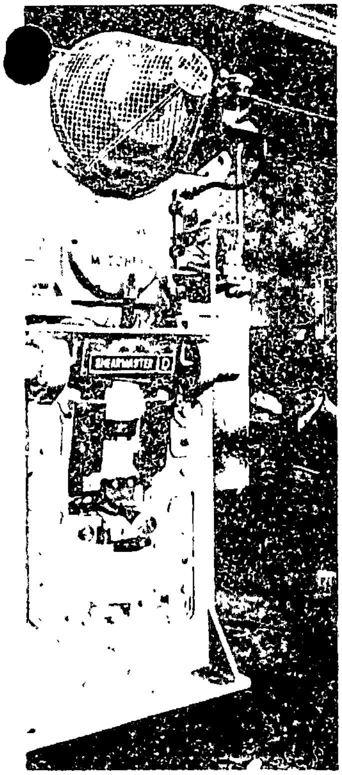
The Wilkins &
production at
and tube mills.
Nearly all stee
There is no wa
Standard sizes
square - 'O' for
Round and rec
Wilkins & Mit
production gua

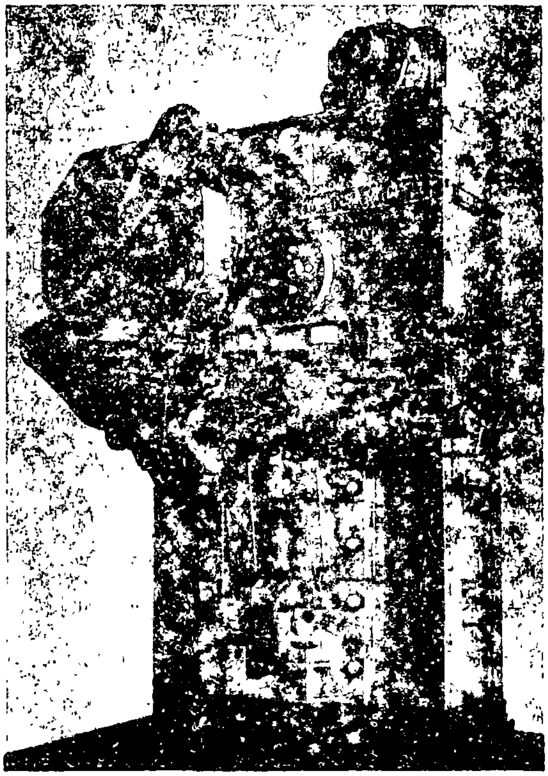
The following fea
Stock feeding rail
if it is outside the
supports the bille


Shearmaster 'D'

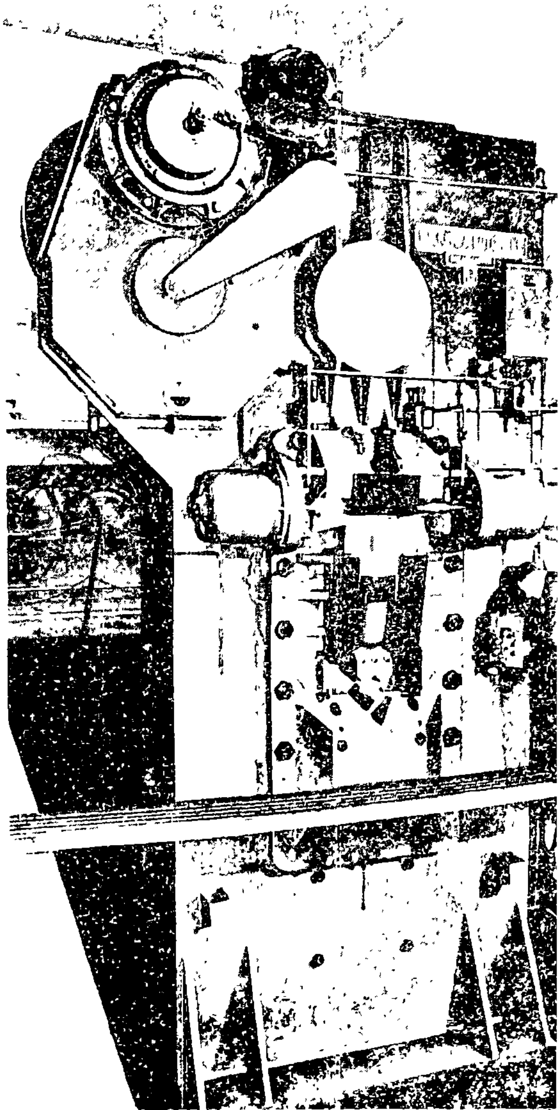
Mitchell 'Shearmaster', a heavy duty billet shear, is designed to give
ow cost in all branches of the forging industry. It is also used extensively in rolling
carriage and wagon shops and in chain-making.
s can be cropped cold. Certain special steels and alloys will require preheating.
ste material.
anufactured are Code 'D' for 3″ square bars - 'F' for 4″ square - 'J' for 5″
″ square - 'U' for 7″ square.
tangular stock can also be sheared.
chell Billet Shears are backed by a world-wide after sales service. This is your
rantee.

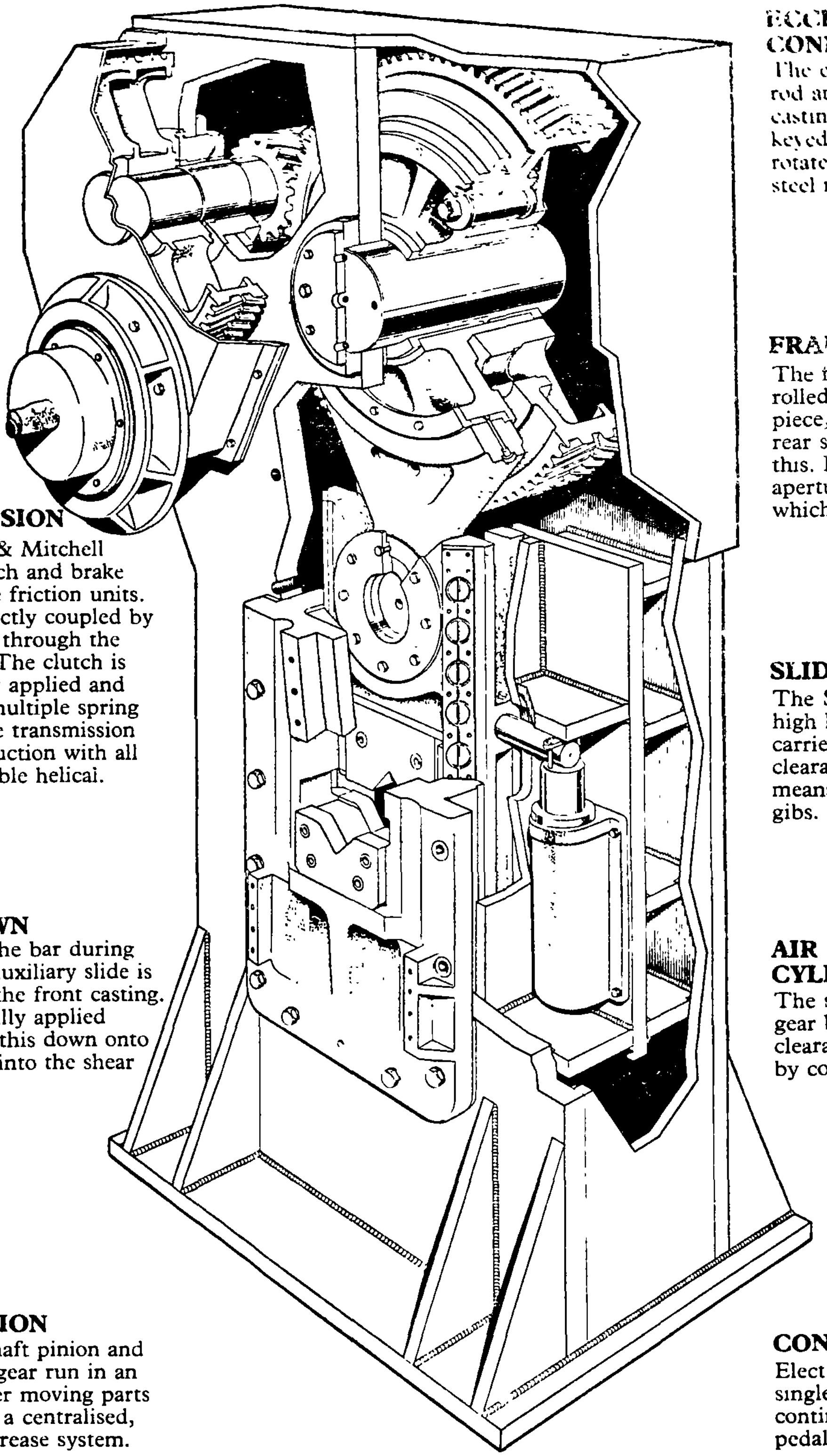
tures can be supplied.
s. An automatic weighing device. This weighs the billet after shearing and stops the machine
weight tolerance. A hydro hold-up device. This mounts a shoe beneath the top blade which
as shearing takes place.





Shearmaster 'O'





ECCENTRIC & CONNECTING ROD

The eccentric and connecting rod are bronze-lined steel castings. The eccentric is keyed to the drive gear and rotates on a stationary forged steel mandrel.

FRAME

The frame is fabricated from rolled steel plate. It is of one piece, solid construction. The rear slideways are carried in this. Bolted in the frame aperture is a steel housing which carries the lower blades.

CLUTCH & TRANSMISSION

The Wilkins & Mitchell designed clutch and brake are multiplate friction units. They are directly coupled by a rod passing through the clutch shaft. The clutch is pneumatically applied and the brake is multiple spring operated. The transmission is double reduction with all gears cut double helical.

SLIDE

The Slide is a steel casting of high length to width ratio. It carries the top blade. Working clearances are maintained by means of adjustable front 'V' gibs.

HOLD DOWN

For holding the bar during shearing, an auxiliary slide is contained in the front casting. A pneumatically applied wedge forces this down onto the bar close into the shear blades.

AIR BALANCE CYLINDERS

The slide and blade weights, gear backlash and working clearances are counteracted by compressed air cylinders.

LUBRICATION

The clutch shaft pinion and intermediate gear run in an oil bath. Other moving parts are served by a centralised, forced feed, grease system.

CONTROLS

Electric controls provide for single stroking, inching and continuous running. A foot pedal is provided.

WILKINS & MITCHELL

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DISEÑO DE HERRAMENTAL

EXTRUSION

ING. ULRICH SCHARER SAUBERLI.

JUNIO 1978.

Cold Extrusion

with

WILKINS & MITCHELL

Presses

THE WILKINS & MITCHELL COLD EXTRUSION PRESS

The goal of any manufacturing process must be to make components as near as possible to the finished shape in as short a time as possible. Cold extrusion does just this. And in the great majority of cases in just one operation. Just as sheet metal pressing has replaced panel-beating – so cold forming, with all its accuracy, can often replace machining and sometimes hot forging.

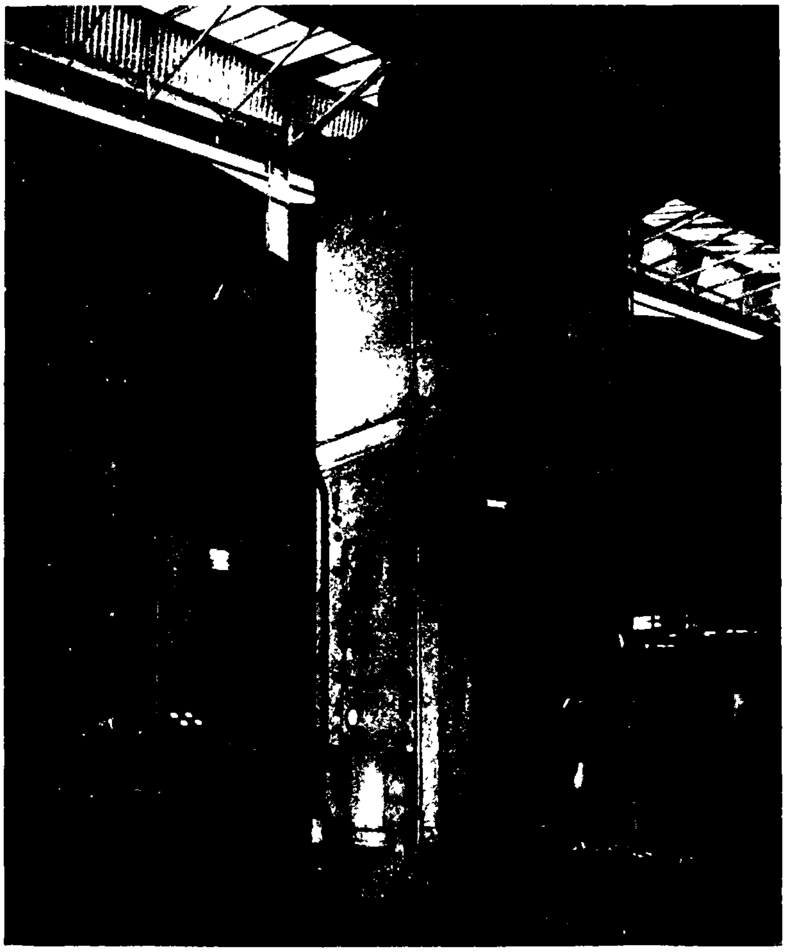
WILKINS & MITCHELL COLD EXTRUSION PRESSES – MAKE COLD EXTRUSION JUST ANOTHER PRESS OPERATION.

THE PROCESS. Cold Extrusion is a manufacturing process for the production of components by deformation under pressure. An unheated billet is placed in a die and simply squeezed by a punch. There are three basic methods of deformation. The first – forward extrusion, through a hole in the die, the second – backward extrusion, upwards into a space between the punch and die and the third–deformation wholly within the limits of the die itself.

THE PRODUCT. Cold extrusion is particularly suited to the manufacture of symmetrical jobs although many non-symmetrical ones are produced, mainly by cold heading. There are two principal shapes in cold extrusion. The first–solid components, which includes stepped shafts and a variety of heads and the second-hollow components with a pre-formed end wall, or hollow components with or without an end wall and with a stepped or toothed outside diameter. A few examples are:– Tubes, cans, studs, bolts, motor shafts, ball joints, gear blanks, gudgeon pins, plug bodies and hydraulic cylinders.

THE SAVINGS. Savings are made in material, scrap and machining costs through the most economical use of the raw material. There is virtually no waste as machining – where required – is fractional. Coupled with these savings we have the high production rates of Wilkins & Mitchell Mechanical Presses.
Components examined after cold extrusion shew increased hardness, increased ultimate strength and a higher yield point. This means greater strength in the material than before extrusion and economies can be made in the selection of a lower grade and therefore cheaper steel.
Cold extrusion as a process is not only associated with large quantity production – it can be found highly competitive for comparatively small numbers.

COLD FORGINGS – RAPIDLY PRODUCED – TO MACHINE SHOP TOLERANCES – OFTEN TO THE FINISHED SHAPE – THAT IS YOUR AIM – AND OURS.



Wilkins & Mitchell Cold Extrusion Presses range from 100 to 3000 tons capacity.

The presses shewn in the photograph are of single point suspension. Their works Code is 0421–16. They are seen in the works of Birfield Extrusions Ltd., Birmingham, England.
Each press is of 750 tons capacity, has a stroke of 16" and operates at 19 s.p.m. Bed areas are 42" x 48" with an overall height of 24' 6", width of 12' 6" and depth 12' 6". Each press weighs 90 tons.
Press Frames consist of four all steel, welded fabrications which are shrunk to one unit by heavy tie bars. Incorporated in these presses are Slide Spring Packs, Shear Plates and Hydro Mechanical Ejectors as described on page 3 and which were specially designed to meet the exacting demands of the Cold Extrusion Industry.

SLIDE SPRING PACK & SHEAR PLATE

The Slide Design of the Press Code 0421-16 shewn on page 2 incorporates a pre-load unit of disc springs which absorbs the initial shock when the load is applied to the slide. This spring pack of seven nests of springs is pre-compressed to 50 tons and will build up to the press capacity of 750 tons. There will be a spring deflection of 0·2" when this takes place, the connecting rod, screw and nut moving down – relative to the slide face – by this amount.

Press and Tools, during an excessive overload, are also safeguarded by a shear plate built into the slide.

HYDRO-MECHANICAL EJECTOR

The Press Bed of the Press Code 0421-16 is equipped with a 150 ton capacity extrusion ejector. It has a stroke capable of adjustment up to a maximum of 8". The ejector can be made to operate at any time during the return stroke of the press — the dwell being controlled by a solenoid operated air valve. This valve is timed at the Rotary Limit Switch.

The hydraulic ejector cylinder is joined by tie rods to the press slide and moves up and down with the press. In this cylinder is a piston which imparts thrust to the ejector rod by means of fluid pressure. Valves built into the piston control the flow of oil in the cylinder and provide the means for "free stroking" of the cylinder relative to the ejector rod.

Stroke adjustment of the piston, up to 8", is by motor driven worm and screw and is positioned above the stroke adjustment air cylinder. Limit-switches protect the unit from being over-set. A visual stroke indicator is provided at the press control panel.

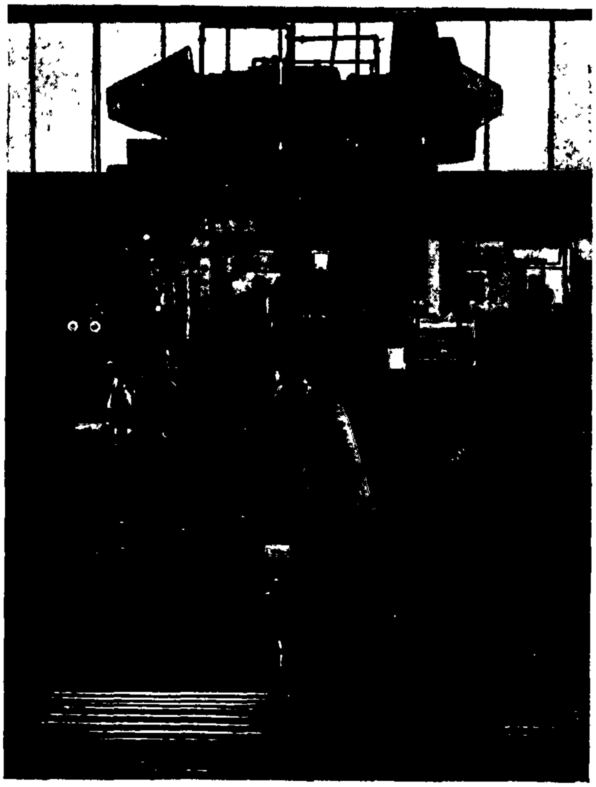
WHILE THE SPRING PACKS, SHEAR PLATES AND HYDRO MECHANICAL EJECTORS WERE FITTED TO 0421-16, OTHER METHODS OF OBTAINING SIMILAR RESULTS CAN BE SUPPLIED WHERE THE COMPONENT IS SUITABLE.

HYDRAULIC OVERLOAD PROTECTION DEVICES CAN BE SUPPLIED FOR HEAVY DUTY PRESSES WHERE APPLICABLE.

OTHER TYPES OF BOTTOM EJECTORS WHICH CAN BE INCORPORATED INCLUDE MECHANICAL i.e. CAM AND OR LEVER-OPERATED, PNEUMATIC AND OR HYDRAULIC.

THE WILKINS & MITCHELL CROPPING & DUMPING PRESS

When backward extrusions are to be produced some dumping and pre-forming will be necessary on the billet. For this purpose we have produced a range up to a capacity of 800 tons of Dumping and Pre-forming Presses which will also crop bars to the lengths required. These unheated billets pass into the pre-forming tools and are formed into the needed shapes for subsequent back extrusion.



Shewn in the photograph is a two point suspension Press Code C362–10 in the works of the Lockheed Hydraulic Brake Co. Ltd., one of the Automotive Products Group, Leamington Spa, England. Pre-formed billets are being produced after cropping to length on the same machine.

The frame of the press is of all steel, fabricated, tie rod construction.

Press capacity is 150 tons. The stroke is 10" and it runs at 40 s.p.m. Bed area is 36" x 30". Overall height is 14' 0", width 10' 6" and depth 6' 6". Press weight is 16·5 tons.

Important features of this machine are a wedge adjusted bolster plate and an ejector bar which passes through it.

Wedge adjustment of ·75" on the bolster is quickly and easily done manually through a geared reduction box.

A heavy mechanical ejector of 10 tons capacity is positively operated through levers by a cam on the press drive wheel mandrel in the press crown.

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WILKI[illegible] COLD EXTRUSION [illegible]S — [illegible]
PRESS OPERATIO[illegible]

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