United States Patent

Richard et al.

[15] **3,698,273**

[45] **Oct. 17, 1972**

[54] **AUTOMATIC PUNCH PRESS FOR FLEXIBLE METAL BAND**

[72] Inventors: **Yvon L. Richard,** Sebago Lake; **Charles Wojchlwski,** Portland, both of Maine

[73] Assignee: **Rich Tool & Die Company**

[22] Filed: **Feb. 10, 1971**

[21] Appl. No.: **114,385**

Related U.S. Application Data

[63] Continuation of Ser. No. 740,341, June 26, 1968, abandoned.

[52] **U.S. Cl.** **83/183,** 83/188, 83/267, 83/411, 269/57, 279/123

[51] **Int. Cl.**.....**B23d 21/14,** B23d 5/34

[58] **Field of Search**.....83/175, 176, 411, 187, 194, 83/267, 620, 925; 269/297, 298, 299, 153, 156; 279/121, 123

[56] **References Cited**

UNITED STATES PATENTS

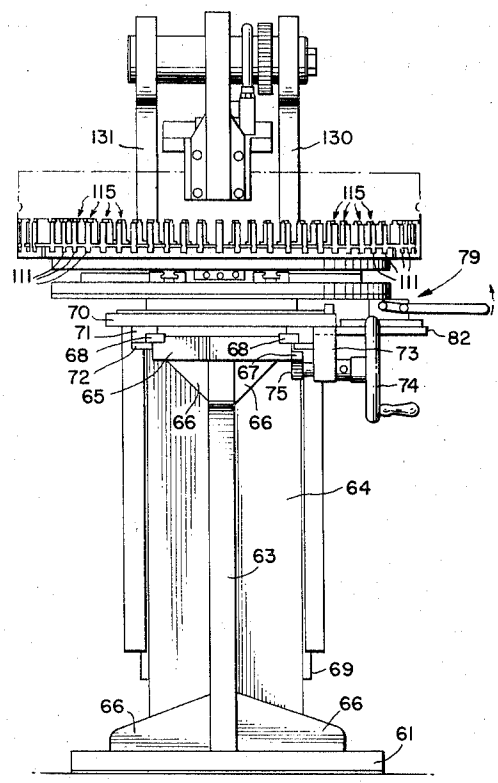
1,219,170	3/1913	Schumann	83/194 X
2,630,862	3/1953	Musser et al.	83/267 X
3,197,220	7/1965	Peterson	279/121

Primary Examiner—Andrew R. Juhasz
Assistant Examiner—Leon Gilden

[57] **ABSTRACT**

A punch press for flexible metal bands such as jet engine cooling bands which holds varying size bands in a true radius on a rotatable table angularly indexing the band past a punching head.

2 Claims, 36 Drawing Figures



PATENTED OCT 17 1972

3,698,273

SHEET 01 OF 12

Fig. 1.

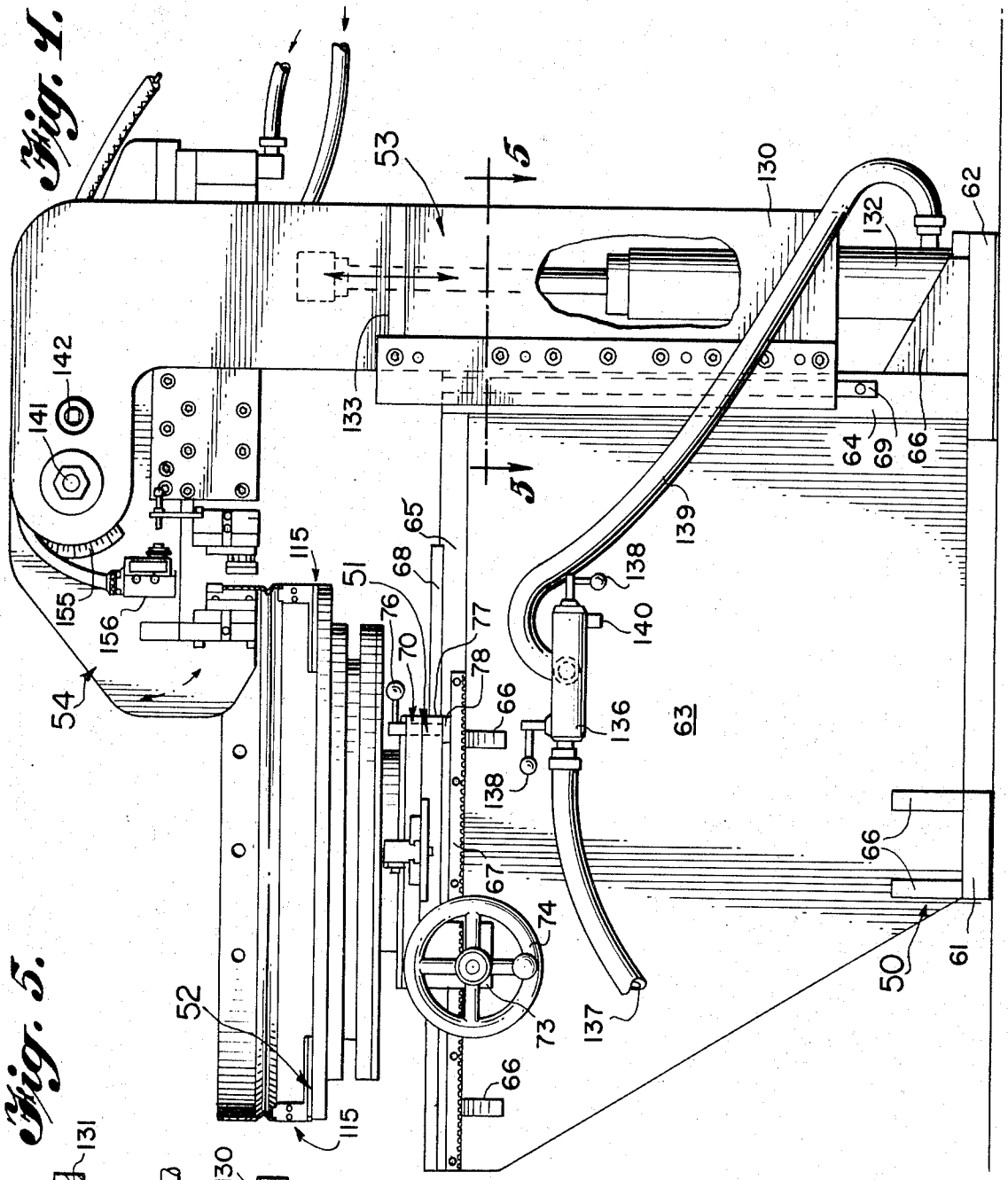
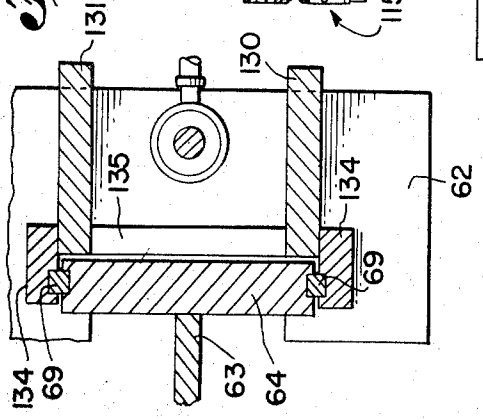


Fig. 5.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 3.
(PRIOR ART)

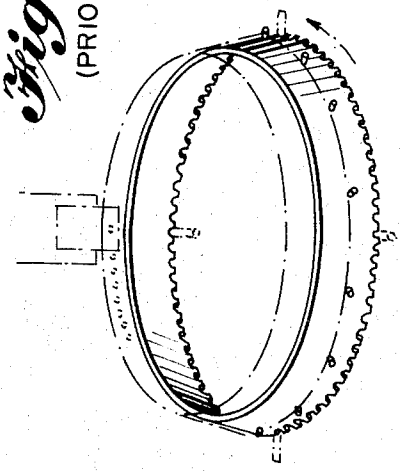
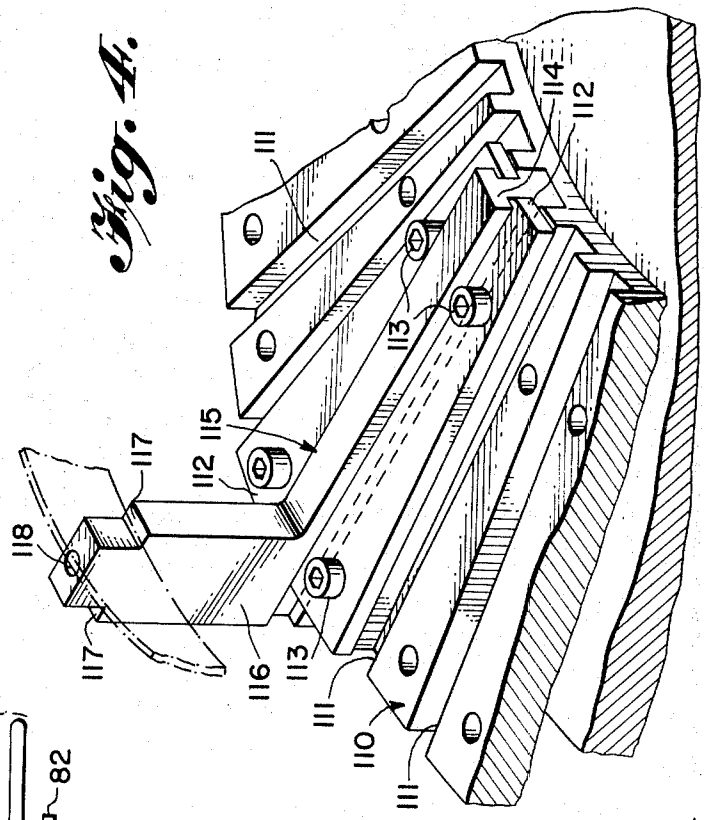


Fig. 4.



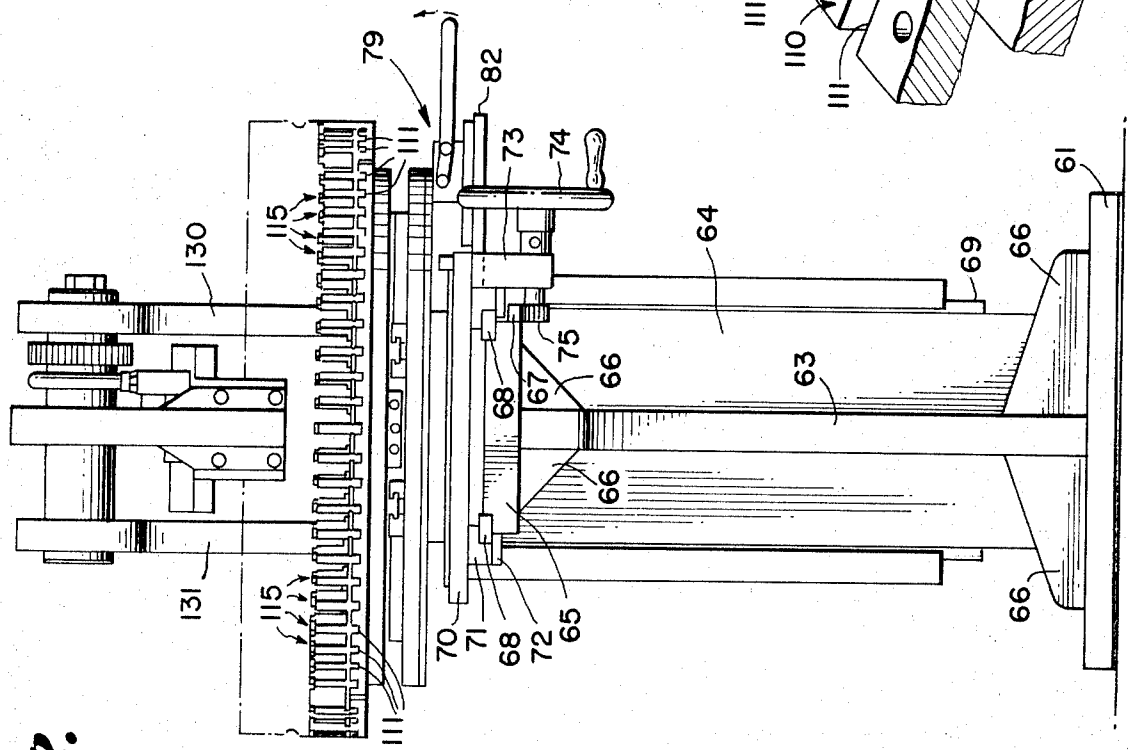


Fig. 2.
(INVENTION)

INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

Fig. 6.

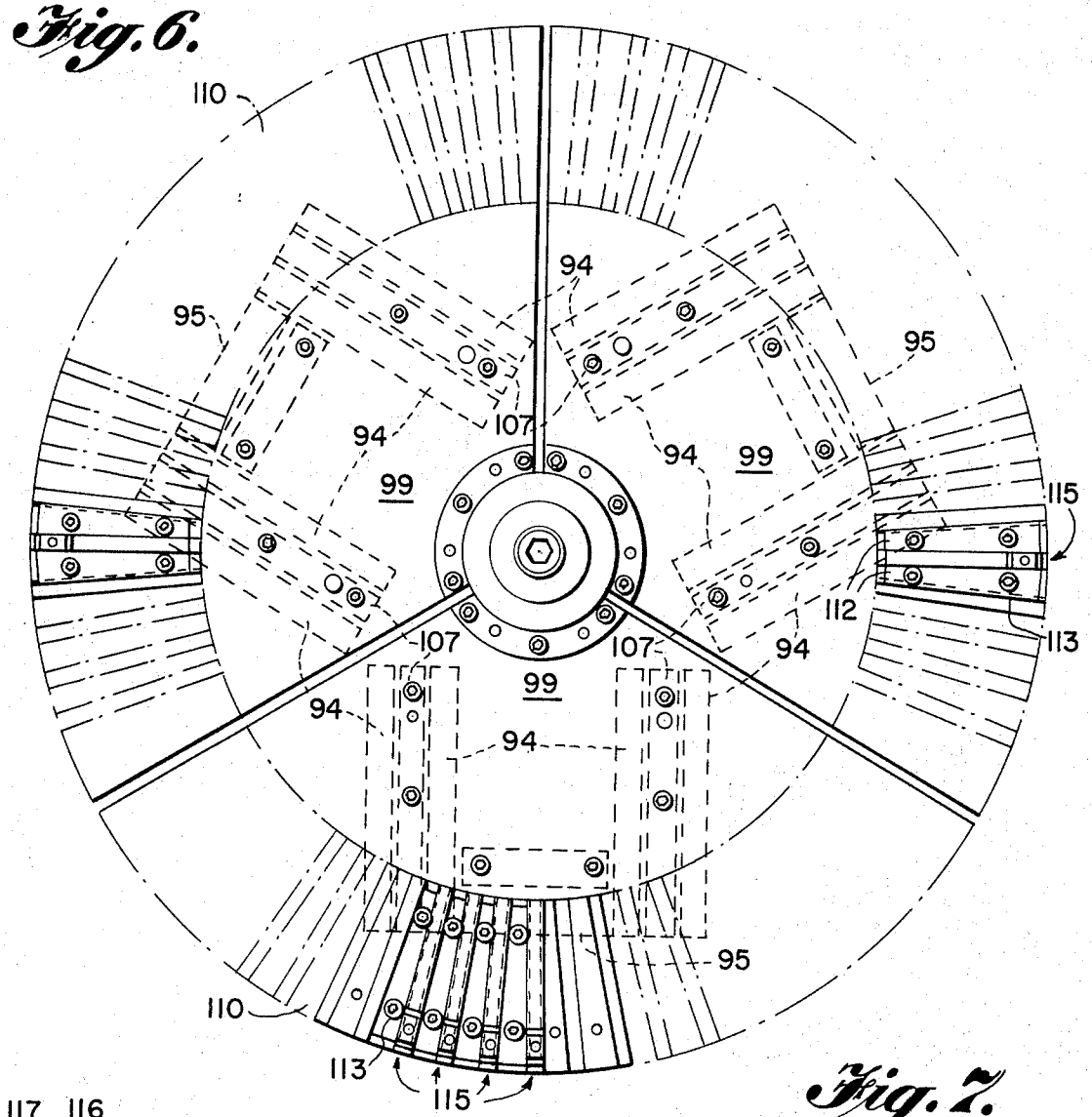
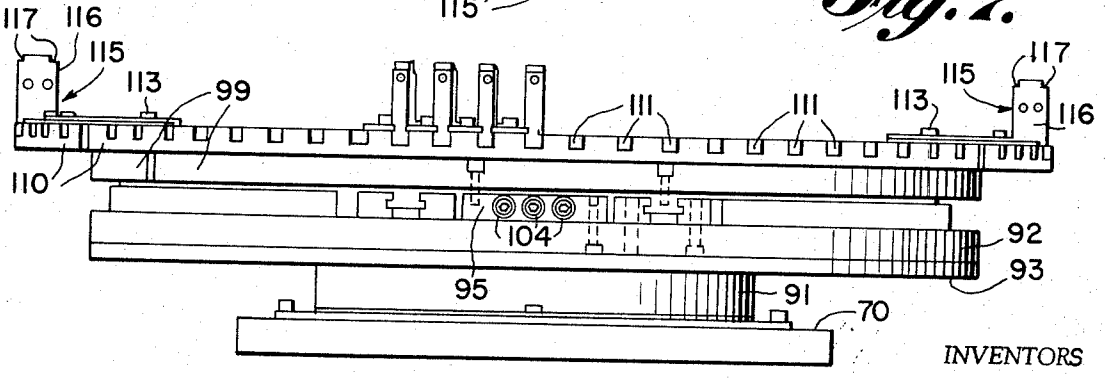


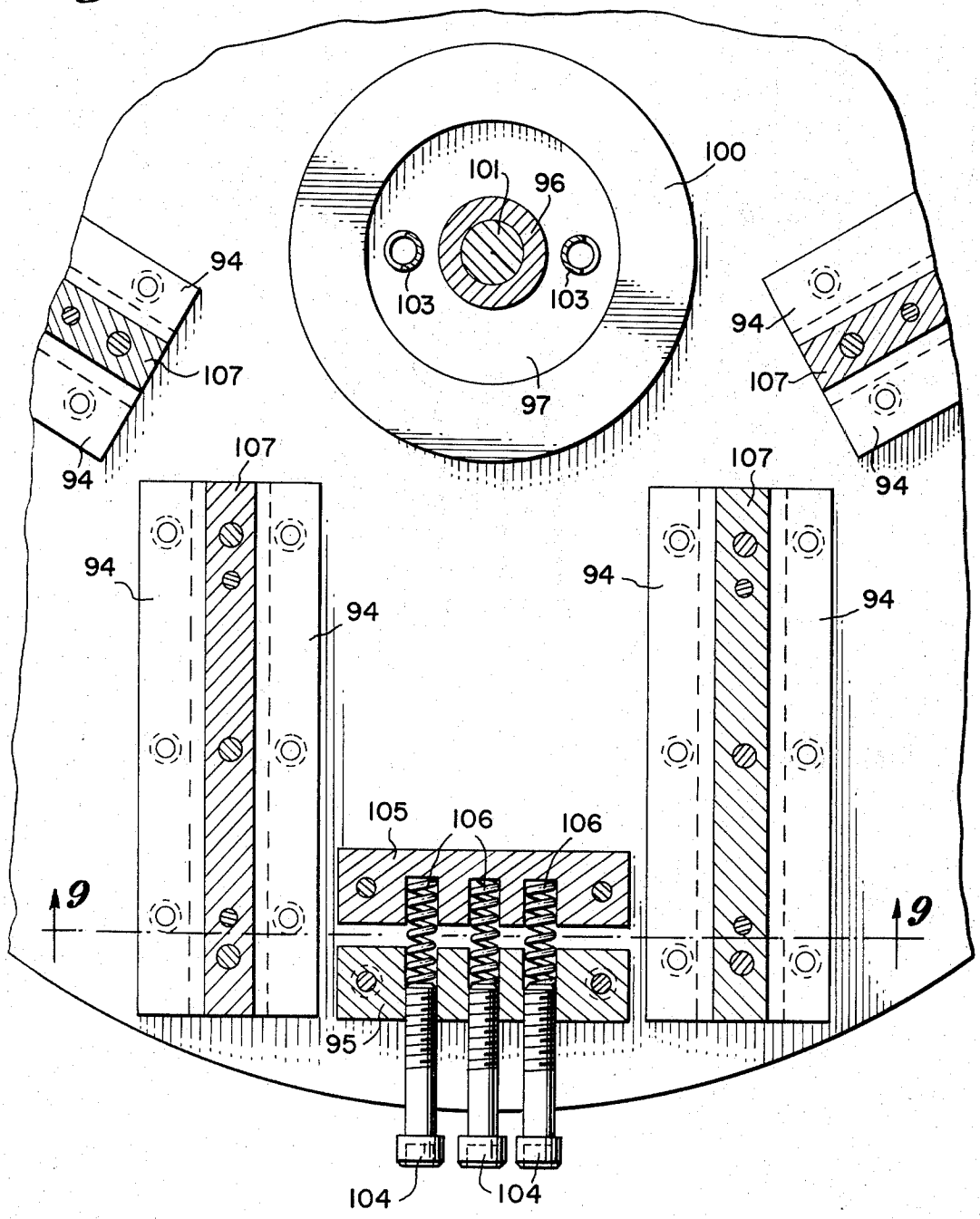
Fig. 7.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 8.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 9.

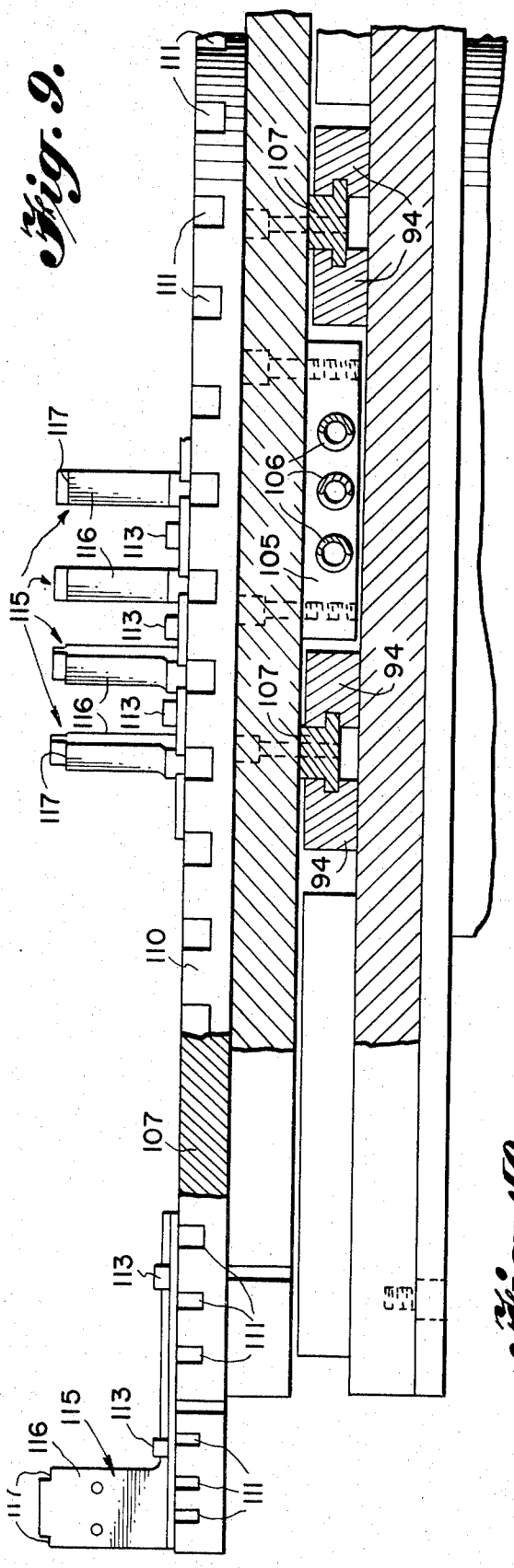


Fig. 12.

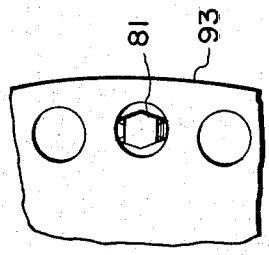


Fig. 10.

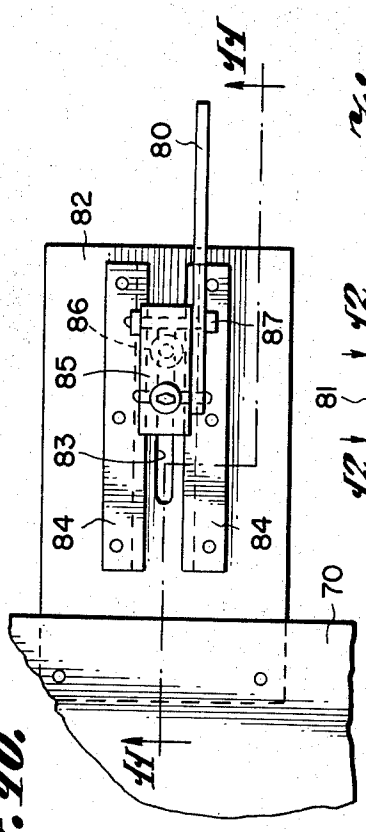
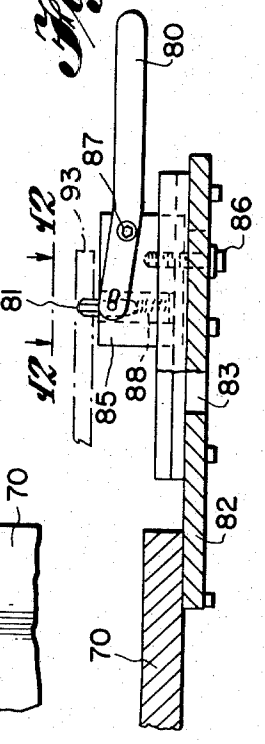


Fig. 11.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

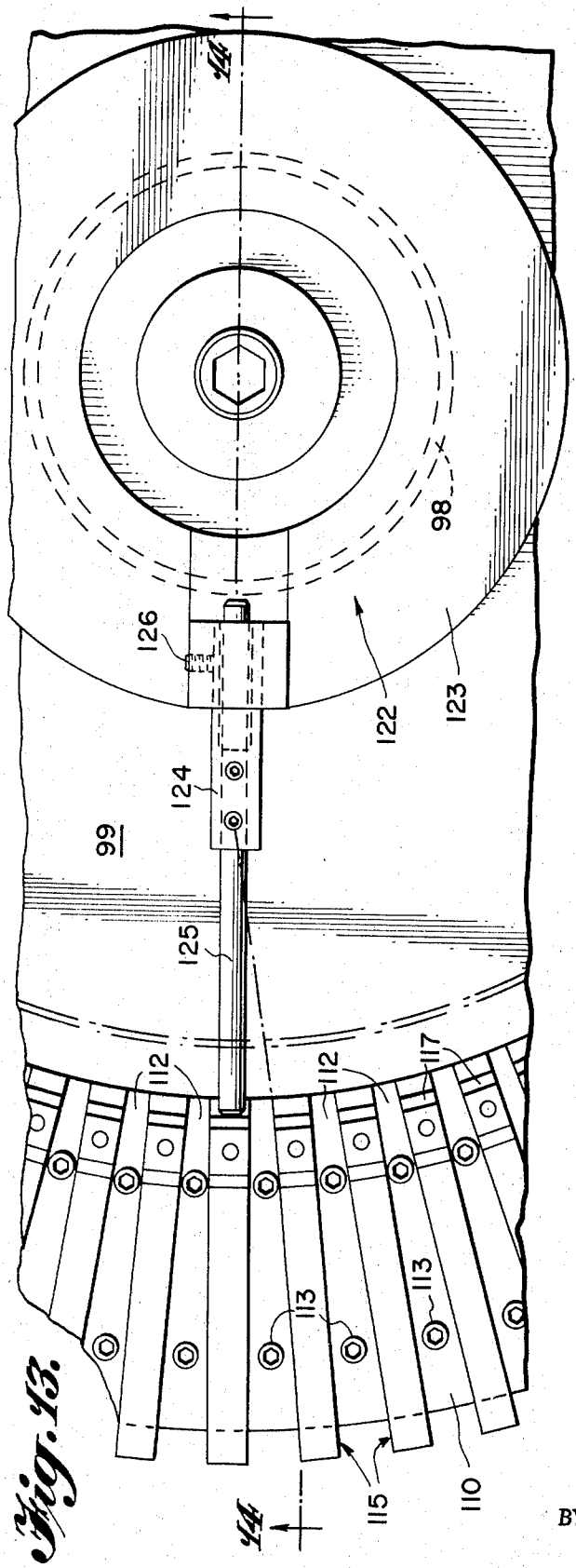


Fig. 13.

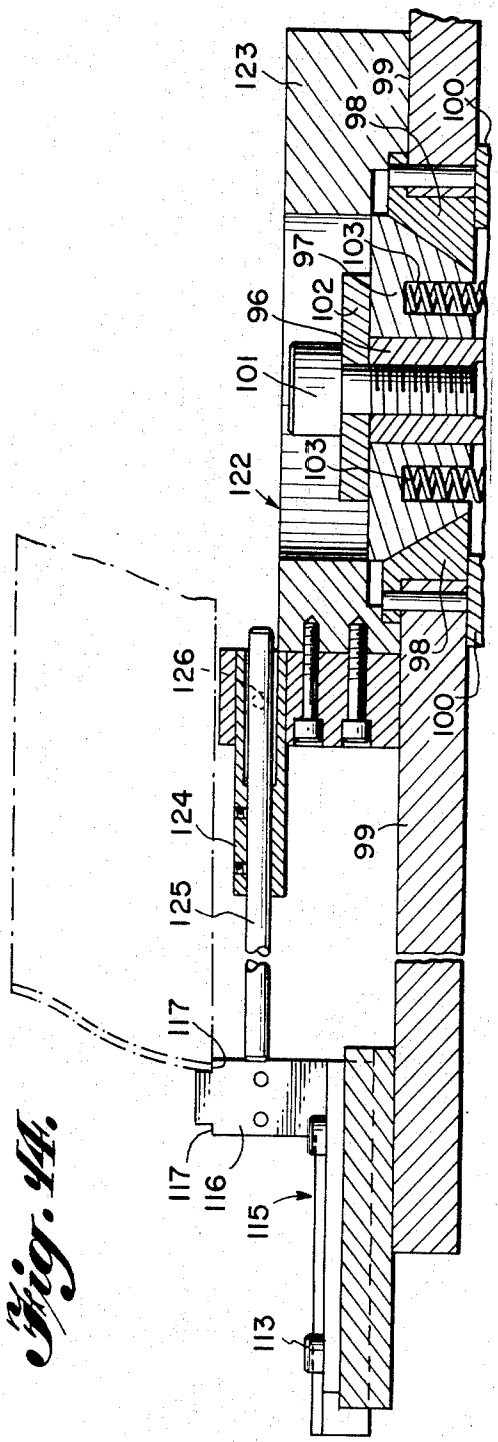


Fig. 14.

INVENTORS

YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 15.

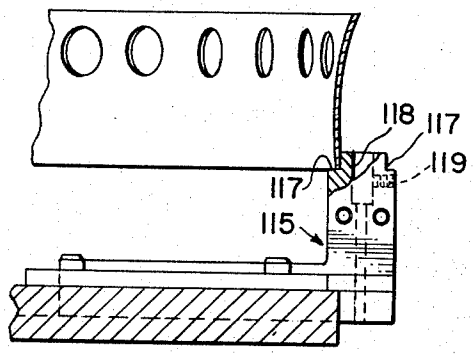


Fig. 16.

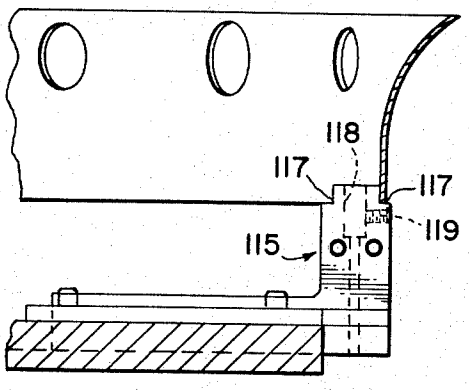


Fig. 17.

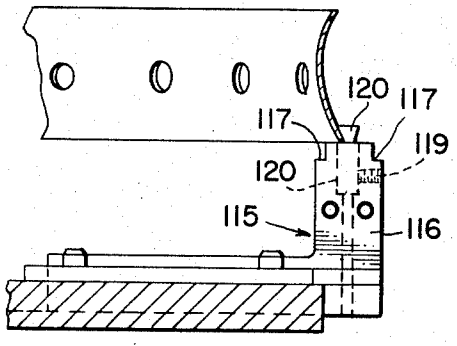


Fig. 18.

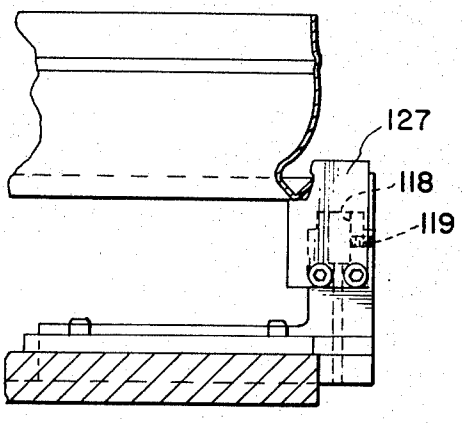
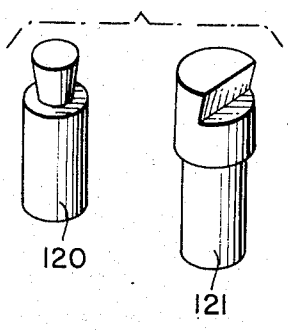


Fig. 19.



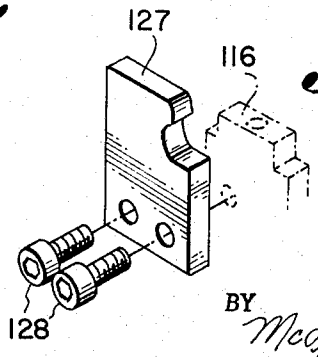


Fig. 20.

INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 21.

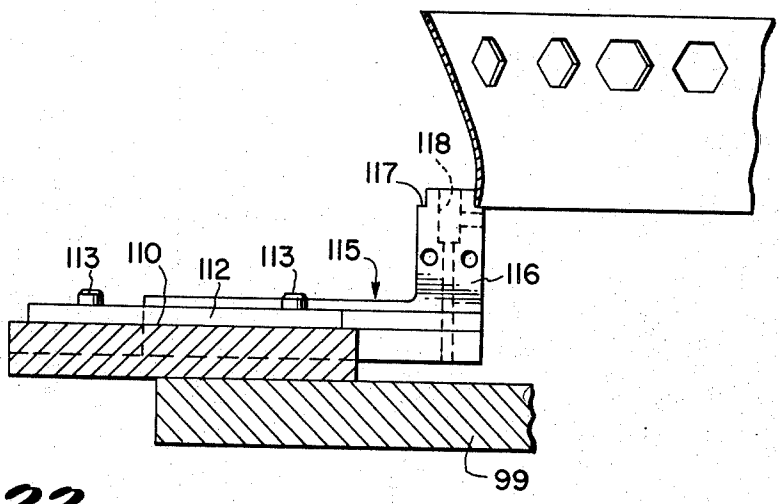


Fig. 22.

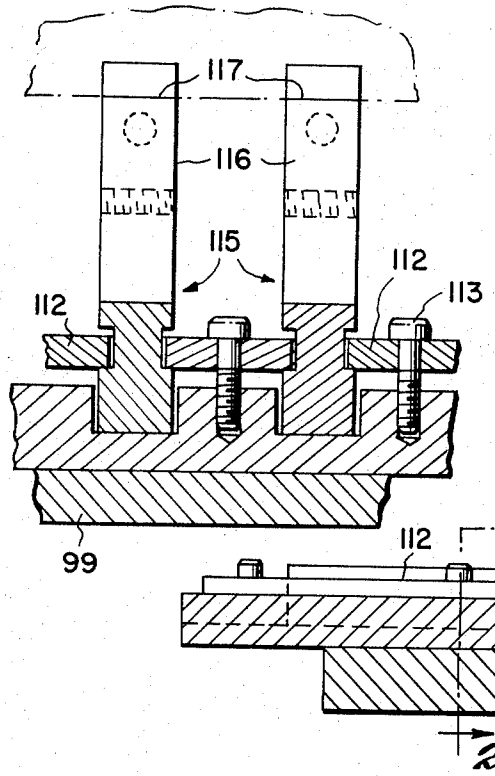
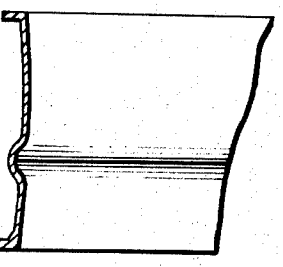


Fig. 23.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

Fig. 24.

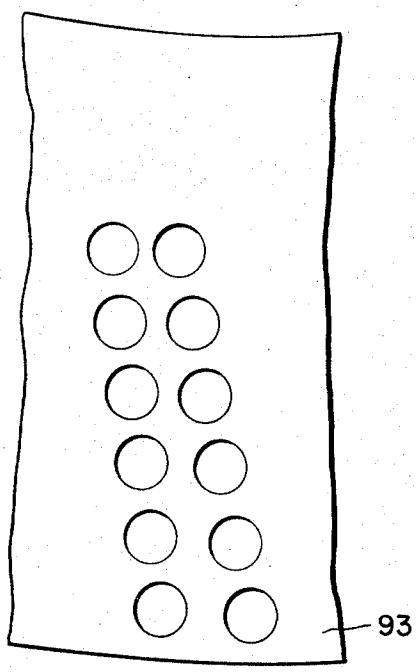


Fig. 25.

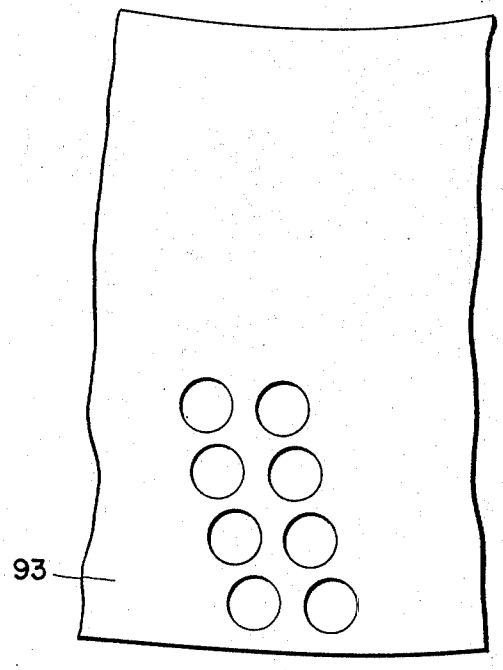


Fig. 26.

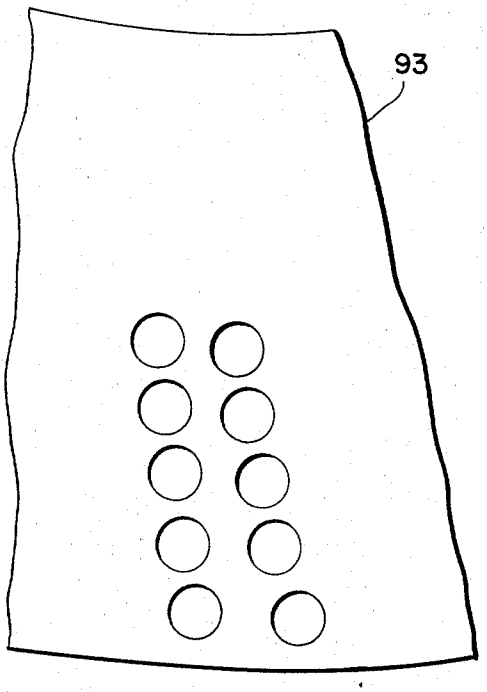
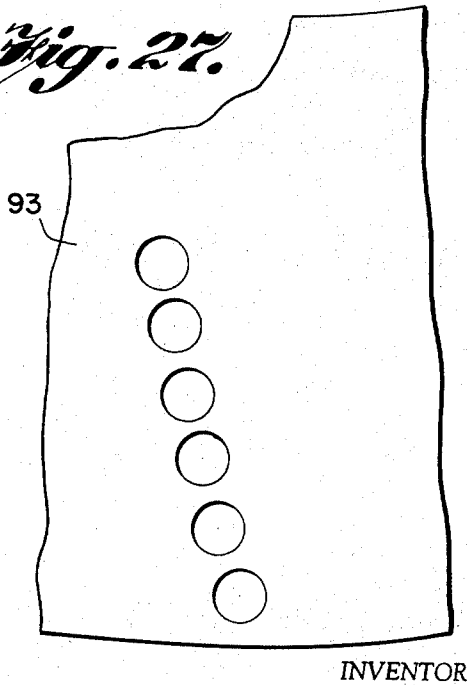


Fig. 27.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

Fig. 28.

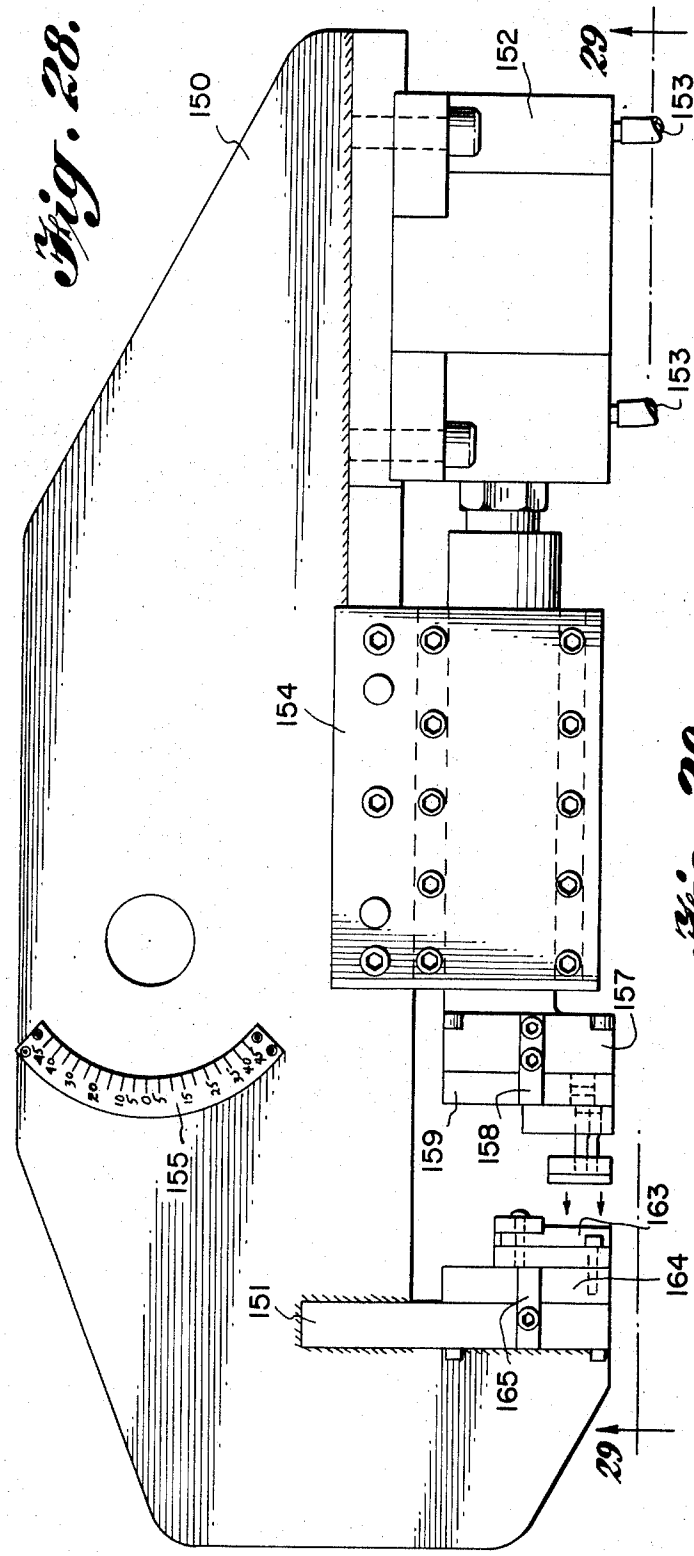
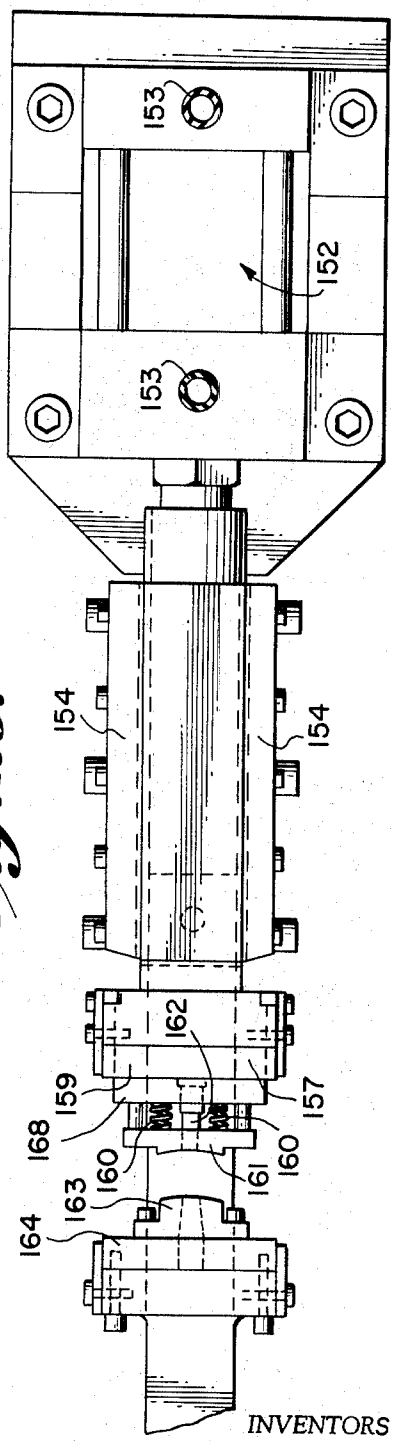


Fig. 29.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

Fig. 30.

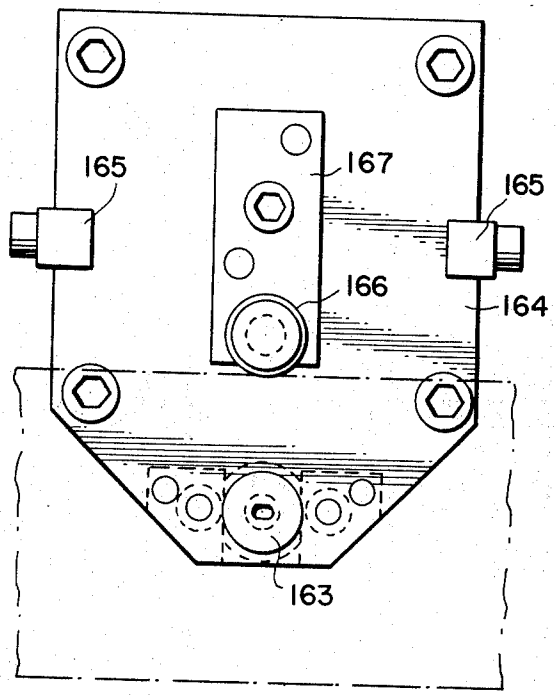


Fig. 31.

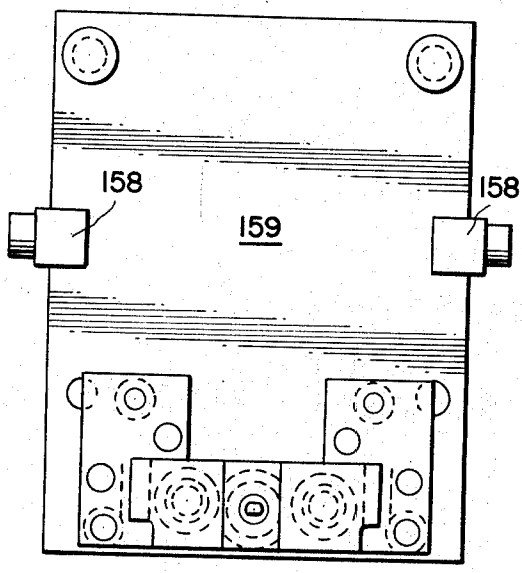


Fig. 32.

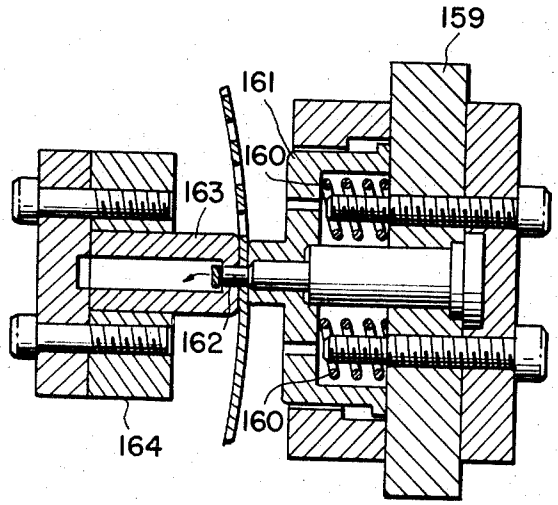
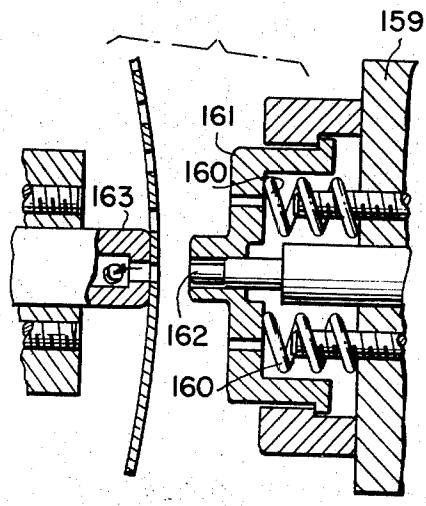


Fig. 33.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY McLean, Morton & Boustead
ATTORNEYS

Fig. 34.

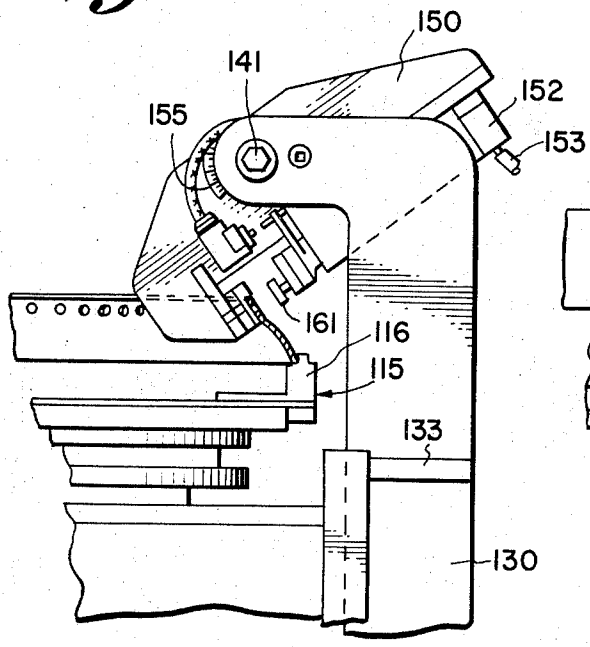


Fig. 35.

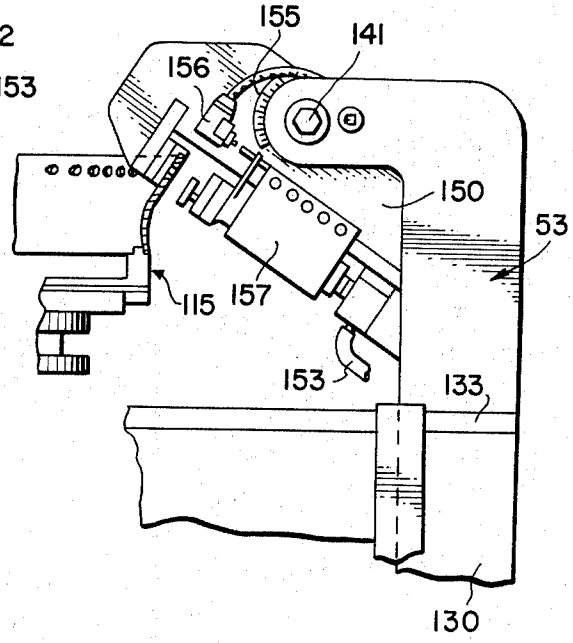
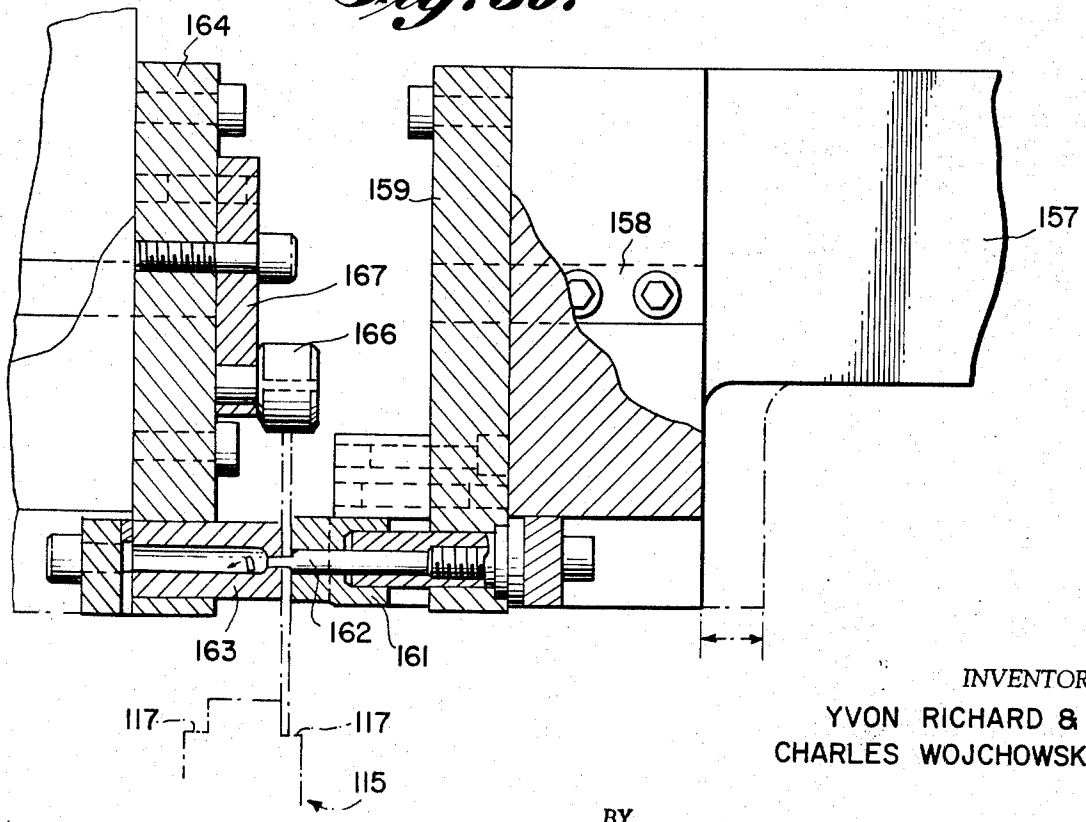


Fig. 36.



INVENTORS
YVON RICHARD &
CHARLES WOJCHOWSKI

BY
McLean, Morton & Boustead
ATTORNEYS

AUTOMATIC PUNCH PRESS FOR FLEXIBLE METAL BAND

This application is a continuation of Ser. No. 740,341, filed June 26, 1968, now abandoned.

BACKGROUND OF INVENTION

An essential element of the modern jet engine are the cooling bands or shrouds. Unlike reciprocating engines where abrasion and friction are important factors, the prime cause of jet engine wear and failure is localized overheating and consequent loss of strength and ultimately failure.

The increased reliability and lengthened service life of jet engines over the last two decades has been, in large part, due to accurate and adequate cooling of every part of the engine. This is achieved by cooling bands and shrouds in which holes are placed to direct the air to the part needing cooling.

These bands are the diameter of the jet engine, which are now up to 6 feet for the supersonic transport (SST). There are 15 or more bands per engine, each several inches wide and approximately one-eighth inch thick. Each band will contain holes which range in diameter from under one-sixteenth to over 1 inch. The number of holes for each band will vary from a few dozen to several hundred.

The design of bands and size and placement of holes is even today largely emperical. Band configurations are modified until one is found which performs properly. Reliability of production engines is accomplished by requiring substantially exact duplication of these emperically developed hole sizings and spacings for the bands.

One method used to punch the required holes in the band is simply to inscribe the proper place for the holes and hold the band by hand in the press. In this method any error in measuring one hole will be transmitted to all subsequent holes as the placement of each is measured from the previous one.

An improvement on the above method is shown in FIG. 3 of the drawings. It is an index ring which is the size and concavity of the band to be punched and is notched with the number of holes which are required. The band is clamped on the ring and a jig containing a placement rod is positioned on the punch press. Each notch is then fitted into the rod and its corresponding hole is punched.

SUMMARY OF INVENTION

This punch press has three advantages over prior art machines and methods for punching holes in jet engine cooling bands. These advantages are the virtual elimination of rejected bands, the speed of changeover and the speed of operation. In summary, they have greatly reduced the cost of producing these bands, itself a major factor in the cost of the jet engines.

The above described manual methods produced a substantial reject rate since the tolerance standards are set at the maximum achievable. The problem is compounded because the bands are not only very flexible and difficult to handle but are not completely uniform in diameter. Therefore measurement along the circumference is not reliable and fit on the index ring is not perfect.

Our machine overcomes these problems by providing an adjustment for the slight size variations and by measuring hole placement angularly not linearly along the circumference.

New size bands and different hole configurations are continuously being ordered. The time required to produce each of these experimental bands largely determines the time required to develop new engines. Using the prior art index rings requires the production of a new ring for each different size or shape of band and each different hole spacing. On our machine, because the band holding and spacing functions have been separated, there is no need for producing special equipment for each new job.

Heretofore the speed of operation has been largely governed by operator fatigue from holding the bands in the precise position during the several hundred punching operations. Each band would take up to several hours by that method while on the current versions of our machine the same job is done in under ten minutes.

DESCRIPTION OF DRAWINGS

Our machine will be further described with reference to the twelve annexed sheets of drawings in which:

FIG. 1 is a side elevation of the punch press;

FIG. 2 is a front elevation of the punch press;

FIG. 3 shows a prior art index ring positioned on a metal band;

FIG. 4 is an enlarged partial perspective of the table assembly and one holding finger;

FIG. 5 is a section view taken on lines 5—5 of FIG. 1 showing the elevating arm assembly structure;

FIG. 6 is a plan view of the carriage assembly;

FIG. 7 is a side elevation of the carriage assembly;

FIG. 8 is an expanded view of the guide mechanism for one segment of the carriage assembly;

FIG. 9 is an expanded side elevation view in a partial section of the carriage assembly taken along line 9—9 of FIG. 8;

FIG. 10 is a plan view of the index ring holding finger;

FIG. 11 is an elevation partially in section taken on line 11—11 of FIG. 10;

FIG. 12 is a partial plan view taken on lines 12—12 of FIG. 11 showing the index ring and plunger;

FIG. 13 is a partial plan view of the carriage assembly showing the diameter setting gage;

FIG. 14 is a sectional elevation taken on lines 14—14 of FIG. 13;

FIG. 15 is an elevation of an index finger and a portion of a slightly concave circular band;

FIG. 16 is a view similar to FIG. 15 showing a band with a greater concavity being held from the inside;

FIG. 17 is a view similar to FIG. 15 showing the holding finger with a circular adapter;

FIG. 18 is a view similar to FIG. 15 for showing the holding finger with a large attached adapter;

FIG. 19 shows two forms of circular adapters for insertion into a holding finger;

FIG. 20 shows the large adapter of FIG. 18 in perspective;

FIG. 21 shows the holding finger reversed to face inwardly for a smaller band;

FIG. 22 is an elevation showing the mounting of the holding fingers on the carriage assembly;

FIG. 23 is a view similar to FIG. 21 showing the holding finger facing inwardly in a small band with a large flange;

FIGS. 24, 25, 26, and 27 show various arrangements of holes in index rings;

FIG. 28 is a side elevation of the punching head;

FIG. 29 is a plan view taken on lines 29—29 of FIG. 28;

FIG. 30 is an front elevation of the punch head;

FIG. 31 is a front elevation of the punch die;

FIG. 32 is a plan section of a punch head during the punching operation;

FIG. 33 is a plan section of the punch head following the punching operation;

FIG. 34 is a side elevation of the punch head tilted downwardly to punch a convex circular band;

FIG. 35 is a similar view of the punch head tilted upward to punch a concave circular band;

FIG. 36 is an enlarged partial section elevation showing the punch head operation.

STRUCTURE

The punch press comprises five major assemblies which are indicated generally in FIG. 1. These assemblies are the base assembly 50, the carriage assembly 51, the index table assembly 52, the elevating arm assembly 53 and the punch head assembly 54.

Base Assembly

The base assembly is shown in FIGS. 1, 2, and 5. The assembly comprises a front rest plate 61 and a rear rest plate 62. Attached to both plates is central vertical plate 63 and attached to the rear plate and the central vertical plate is rear vertical plate 64. On top of the central vertical plate 63 is upper platform 65 which abuts rear vertical plate 64. Further attaching the vertical and horizontal members are reinforcing gussets 66.

Attached to the left lower side, looking forward, of upper platform 65 is gear rack 67 with its teeth facing downwardly. On the upper edge of both the right and left sides of upper platform 65 are carriage ways 68. Protruding from both the right and left sides of rear vertical plate 64 are elevating arm ways 69.

Carriage Assembly

The carriage assembly is shown in FIGS. 2, 10, 11, and 12 and comprises a carriage platform 70 beneath which are two slides 71 mounted to cooperate with carriage ways 68. Beneath slide 71 are slide caps 72 which prevent the carriage assembly from rising off of the carriage ways.

The carriage assembly on one side has a wheel housing 73 on which is a hand wheel 74 connecting to spur gear 75 which cooperates with gear rack 67.

At one end of the carriage assembly in a convenient place above the slide 71 is clamp handle 76, bolt 77 and clamp plate 78 which replaces a portion of slide cap 72.

Disposed adjacent to one side of the carriage platform is locking pawl 79, comprising pawl handle 80 and pawl head 81. Pawl base plate 82 is attached to the underside of carriage platform 70 and has slot 83 and side plates 84 attached thereto. Between and partially below side plates 84 is pawl housing 85 and passing through slot 83 is pawl housing set screw 86.

Pawl handle 80 is pivotally attached to slide plates 84 by rod 87 and the pawl head is biased upwardly by spring 88. Pawl housing set screw 86 is positioned so that pawl head 81 which is hexagonal and slightly conical in shape, as shown in FIG. 12, cooperates with the holes of index plate 93.

Index Table Assembly

The index table assembly is shown in FIGS. 1, 2, 4, 6 through 9, and 13 through 27. Referring to FIG. 7, the assembly contains bearing 91 attached to carriage platform 70. Above bearing 91 is table base plate 92 rotatably mounted to the bearing. The bearing 91 allows the entire index table assembly to rotate freely.

Beneath table base plate 92 is index plate 93. This plate cooperates with the locking pawl 79 to allow the table base plate 92 to be positively and precisely indexed.

My preferred form of index plate utilizes large holes for pawl head 81 and, therefore, as several hundred index positions are often necessary, the holes are spaced in concentric rings as shown in FIGS. 24 through 27. These figures are scale drawings of particular patterns which shows in FIG. 24, six rings with 145 holes per ring for a total of 870 holes on the circumference. FIG. 25 shows four rings of 165 holes for a total of 660 holes on the circumference. FIG. 26 shows five rings of 144 holes for a total of 720 holes on the circumference and FIG. 27 shows six rings of 132 holes for a total of 792 holes on the circumference.

As shown in FIG. 6 the upper part of the index table assembly, the segment plate, is in three parts so that it may uniformly expand or contract as later described under the operation of the punch press. Attached to the table base plate 92 are three pairs of two-piece slide rails 94. Each pair of slide rails are mounted in parallel alignment. Perpendicular to each set of slide rails 94 and also on base plate 92 are outer spring retainers 95.

As shown in FIG. 14, also attached to the axis of rotation of bearing 91 is clamping bushing 96. Journaled on clamping bushing 91 is inner cam ring 97 which cooperates with three-piece outer cam ring 98. The outer cam ring 98 is attached to the inner portion of three-piece segment plate 99. Both of the segment plate 99 and the outer cam ring 98 are supported above the table base plate 92 by a spacer ring 100.

The inner bore of the clamping bushing 96 is threaded to receive camming bolt 101 which together with thrust ring 102 adjustably depresses inner cam ring 97. The inner cam ring is biased upwardly from the table base plate by springs 103. As shown in FIG. 8 the segment plates 99 are biased inwardly by set screws 104 operating through the outer spring retainer 95. Disposed inwardly from the outer spring retainer and attached to the segment plate is inner spring retainer 105 and in the cooperating bore of both elements are retainer springs 106. Also attached to each segment plate 99 are a pair of slides 107 which cooperate with slide rails 94 to retain and guide the travel of the segment plate.

As shown in FIGS. 4 and 6, mounted on the upper side of each segment plate 99 near the outer diameter is holding finger base plate 110. Each holding finger base plate contains a series of parallel rectangular recesses 111.

Mounted above each raised portion of the holding finger base plate 110 and extending over the holding finger recess 111 on each side of the raised portion is holding finger retaining plate 112. These are mounted

to the base plate by set screws **113**. Slideably mounted in each recess is the base portion **114** of holding fingers **115**. The base portion is also recessed to cooperate with the retaining plates **112**.

At one end of the holding finger **115** is upright **116**. On top of upright **116** are internal and external recesses **117** and bore **118**. Fitted into bore **118** and held by set screw **119** are dowels **120**, and **121**. Dowel **120** has a conical head to hold curved bands as shown in FIG. **17** and dowel **121** has an expanded and recessed head for the same purpose.

Holding finger adapter **127** is attached by screws **128**. This adapter is used for bands with a crimped or other unusual base as shown in FIG. **18**.

As shown in FIGS. **21**, **22**, and **23** the holding finger may be reversed in recess **111** having its upright disposed internally thus allowing the clamping of much smaller bands.

Shown in FIGS. **13** and **14** is diameter setting gauge **122**. This gauge is used to locate the subject of the holding fingers and is removed prior to the clamping of the bands. The gauge contains a locating ring **123** the inner surface of which engages the top of the three-segment outer cam ring **98**. When using the gauge the inner cam ring is withdrawn and the segment plates **98** are fully contracted. This portion of the locating ring freely but securely rotates on outer cam ring **98**.

Attached to locating ring **123** is radial rod retainer **124** containing a bore in which is placed radial rod **125**, here shown including a sleeve which is held in position by set screw **126**.

Elevating Arm Assembly

The elevating arm assembly is shown in FIGS. **1**, **2**, **5**, **34**, and **35**. The elevating arm assembly has two vertical elevating arm shafts **130**, **131** which are attached by horizontal elevating arm support block **133** and vertical elevating arm spacer block **135**. The elevating arm assembly has slides **134** attached to the forward sides of shafts **130**, **131** which cooperate with elevating arm ways **69**.

The elevating arm assembly is raised and lowered by ram **132** which is controlled by valve housing **136**. The housing is fed by compressed air supply **137**, contains inlet and exhaust control valves **138**, has exhaust port **140** and is connected to ram **132** by compressed air line **139**.

At the top of the elevating arm assembly is punch head shaft **141** and punch head rotator **142** interconnected by suitable gearing which is not shown.

Punch Head Assembly

The punch head assembly is shown in FIGS. **1**, **2**, and **28–36**. The punch head frame **150** is journaled through punch head shaft **141** to the elevating arm assembly and its angular displacement is shown by angular guide **155**.

At one end of the punch head frame is punch head bed **151** and at the other is hydraulic two way cylinder **152** controlled through hydraulic lines **153** by a foot switch, now shown, and by limit switch **156**. The hydraulic cylinder is connected to punch ram **157** which is supported by two slide side plates **154**.

Cooperating punch and die sets of the size required are connected to the ram and bed respectively by punch keys **158** and die keys **165**. These punch and die sets are all interchangeable to allow for different punching operations.

The punch set includes punch adapter plate **159**, punch holder **168**, biasing springs **160**, punch shroud **161** and punch **162** operating through the aperture of the punch shroud.

The die assembly includes die **163**, die adapter plate **164**, band roller **166** and band roller mounting plate **167**.

OPERATION

Our machine will be further described with reference to the five principal operations which are the setup of the table, the setting the punch, the mounting the band, the rotating the band, the punching the band.

Setup of the Table

The first operation in setting up the table for punching holes in a band is the removal of the table from the carriage and attachment to the table base plate **92** of an index plate **93** containing the same number of holes as are to be punched in the band. Four configurations of index plates are shown in FIGS. **24–27**.

The index plate could of course contain a multiple of the desired number of holes or contain desired number in any one of the concentric rings. The index ring could also contain fewer holes than those desired, such that the number of holes desired to be punched in the band when divided by an integer (i.e., 3, 5, or 8) would equal the number of holes on the index ring. In this case the locking pawl **79** could contain a vernier adjustment to hold the index plate at differing positions corresponding to the dividing integer.

After the index plate **93** has been attached and the table reattached to the carriage, the camming bolt **101** is loosened to withdraw inner cam ring **97** and retract the segment plates **99** together with outer cam rings **98**.

Diameter setting gauge **122** is then placed over the outer cam rings **98** with the lower inner edge of locating ring **123** abutting the outer edge of the cam rings.

The radial rod **125** is then set to the proper distance for the band to be punched. This distance will depend on what portion of the holding fingers **116**, dowels **120**, **121** or adaptor **127** are in contact with the band. As shown the rod contacts the inner edge of the upright, not the actual band holding surface. Taking the above factors into account, the radius rod is set so that the holding surface of the fingers will be in a radius just slightly less than the radius of the band.

All of the set screws **118** are loosened so that the holding fingers **115** may slide freely in the holding finger recess **111**, and either the dowels or adaptor plate is set at each holding finger if desired. The diameter setting gauge is swung around and each holding finger is set to the proper distance. The set screws **118** are then tightened, thus locking the holding fingers in the proper radial setting.

Setting the Punch

The desired size punch and die set is installed on a punch adaptor plate **159** and the die adaptor plate **164** by punch keys **158** and die keys **165**. Band roller mounting plate **167** and band roller **166** are adjusted to give the proper clearance between the roller and the die **163**. The reason for this roller is that specifications for hole location are with respect to one edge of the band and the band roller thus serves to ensure the proper spacing as the band is rotated past the punch and die set.

Mounting the Band

The diameter setting gauge is removed and if the band is to be held from the inside it is placed over the holding fingers utilizing the slight clearance provided by setting fingers inside of the correct diameter as previously mentioned. The band is then secured in place by tightening camming bolt **101**, depressing the inner cam ring **97** and forcing cam rings **98** and segment plates **99** outwardly. Due to the number of holding fingers contacting the band a relatively slight force by camming ring **97** will securely hold the band in position.

If the band is to be held from the outside the camming ring is first depressed and the segment plates and fingers expanded beyond the true diameter of the band. The band is then put in place, the inner camming ring withdrawn and the band is held in position by the retainer springs **106** forcing the segment plates and holding the fingers inwardly.

The carriage assembly and band is then moved by hand wheel **74** to the proper position for punching. Once in the proper position, clamp handle **76** is tightened to prevent further movement of the carriage or table assembly other than the free rotation provided by bearing **91**.

The elevating arm is then adjusted to the proper height by cam **132** and the punch is tilted to the desired angle by punch head rotator **142**.

Rotating the Band

As shown in these drawings, the band is rotated manually by the operator. The locating pawl **79** is set so that pawl head **81** cooperates with the desired holes of index plate **93**. If the index plate has several concentric series of holes the locking pawl is set for each series in sequence. The operator raises pawl handle **80** thus depressing pawl handle **81** and moves the carriage slightly. Pawl head **81** will automatically engage the following hole under action of biasing spring **88**.

While a manual indexing system has been disclosed it would be apparent that any conventional type of automated system would be substantially faster and can be installed on this machine without altering its nature.

Punching the Band

The punching operation follows each indexing step. For an automatic machine it may be intercommunicated with the indexing mechanism or it may be separately activated by the operator. As shown, the punching operation is controlled by hydraulic cylinder **152** and hydraulic lines **153**. A limit switch **156** is included in the hydraulic supply line **153** to release pressure once the punch operation is completed. As shown in FIG. **29**, a punching shroud **161** is utilized for punching holes with a diameter smaller than the thickness of the band itself.

We have described one embodiment of our invention as required by law. It will be apparent to those having skill in the art that modifications on the disclosed embodiment can be made without departing from the scope of the invention. We therefore desire not to be limited by the foregoing description but only by the following claims.

It is claimed:

1. In a machine for automatically punching a series of uniformly spaced holes in a flexible metal band such as cooling holes in a shroud for a jet engine, the combination including:

a. a chuck for holding said bands during punching,

b. said chuck freely rotatable about an axis to allow punching of said bands,

c. a plurality of substantially flat and wedge shaped segment plates mounted on said chuck,

d. said segment plates occupying substantially the entire plane around said axis,

e. each of said segment plates radially movable over an adjusting distance,

f. each of said segment plates having mounted thereon a plurality of radially oriented adjusting fingers,

g. said fingers closely spaced across the width of the segment plate whereby said fingers occupy substantially the entire circumference of the chuck,

h. each of said fingers having a body adjoining said segment plate and having an upright portion extending parallel to said axis, each upright portion adapted to functionally engage and hold a portion of said metal band,

i. each of said fingers on each of said segment plates being individually radially adjustable,

j. clamping means between each of said fingers and its segment plate whereby the band engaging portion of each finger can be set at a distance from the axis equal to the radius of the flexible metal band,

k. distance adjusting means common to all segment plates whereby said distance from the axis to the band engaging portion of the fingers may be altered in an amount sufficient to place the band in position with the fingers and further whereby the distance may be adjusted in the opposite direction to firmly grip the band,

1. indexing means to rotatably index the chuck through a predetermined angular distance, whereby a flexible metal band is held firmly in a predetermined position during a punching operation.

2. In a machine for automatically punching a series of uniformly spaced holes in a flexible metal band such as cooling holes in a shroud for a jet engine, the combination including:

a. a chuck for holding said bands during punching,

b. said chuck freely rotatable about an axis to allow punching of said bands,

c. a plurality of substantially flat and wedge shaped segment plates mounted on said chuck,

d. said segment plates occupying substantially the entire plane around said axis,

e. each of said segment plates radially movable over an adjusting distance,

f. each of said segment plates having mounted thereon a plurality of radially oriented adjusting fingers,

g. said fingers closely spaced across the width of the segment plate whereby said fingers occupy substantially the entire circumference of the chuck,

h. each of said fingers having a body adjoining said segment plate and having an upright portion extending parallel to said axis, each upright portion adapted to functionally engage and hold a portion of said metal band,

i. each of said fingers on each of said segment plates being individually radially adjustable,

j. clamping means between each of said fingers and its segment plate whereby the band engaging por-

tion of each finger can be set at a distance from the axis equal to the radius of the flexible metal band,

k. distance adjusting mans common to all segment plates whereby said distance from the axis to the band engaging portion of the fingers may be altered in an amount sufficient to place the band in position with the fingers and further whereby the distance may be adjusted in the opposite direction to firmly grip the band,

l. indexing means to rotatably index the chuck through a predetermined angular distance, whereby a flexible metal band is held firmly in a predetermined position during a punching operation,

m. a punch and die set movable to engage the band in the desired position during rotation and to there punch the required hole.

* * * * *