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# SELECTION OF EQUIPMENT FOR ASSEMBLING WOOD STRUCTURES AND FRAMES USING METAL CONNECTORS[1/]

by

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Automated Building Components (Australia) PTY. Limited,
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dans l'industrie du bois

Vienne, 19-23 novembre 1973

RESUME

# CHOIX DU MATERIEL UTILISE POUR L'ASSEMBLAGE D'OUVRAGES ET D'OSSATURES EN BOIS AU MOYEN DE CONNECTEURS METALLIQUES[1/]

par
John G. Stokes, Directeur
Automated Building Components (Australia) Pty. Limited
Springvale, Victoria (Australie)

On trouve sur le marché de nombreux matériels pour l'assemblage de charpentes en bois, mais seules la presse frappeuse et la presse à contrepoids en C sont à recommander pour réaliser l'assemblage des feuillus dans les premières phases de l'industrialisation d'un pays en voie de développement.

Si l'on utilise la presse à contrepoids en C, celle-ci doit avoir une force suffisante pour enfoncer les connecteurs à fond. Elle doit aussi être suffisamment rigide pour qu'il n'y ait pas de basculement du châssis.

C'est pourquoi, si l'on envisage d'acheter ce type de presse, on devra envoyer au fabricant des échantillons de bois durs locaux en quantité suffisante pour qu'il puisse réaliser l'assemblage d'au moins trois charpentes en treillis complètes. On pourra ainsi faire l'essai du matériel et des connecteurs retenus.

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1/ Résumé rédigé par le Secrétariat de l'ONUDI. Les opinions exprimées dans le présent document sont celles de l'auteur et ne reflètent pas nécessairement les vues du Secrétariat de l'ONUDI.

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United Nations Industrial Development Organization

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L'empêchement [illegible] une face d'un assemblage, mais que [illegible] s'applique [illegible] pièces [illegible] système, il [illegible] calculement.

Il est recommandé [illegible] préférant l'acheteur [illegible]

Bien que l'usage [illegible] il [illegible] que dans les ateliers d'assemblage [illegible] recommandé d'installer, il suffira de deux scies Unipoint [illegible] l'une à l'autre sur un chevalet pour produire jusqu'à une centaine de charpentes en huit heures de travail.

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ONUDI

RESTRINGIDA

Organización de las Naciones Unidas para el Desarrollo Industrial

Reunión técnica sobre [illegible] para trabajar la madera

Viena, 17 - 21 noviembre 1975

ORIGINAL: INGLES

# SELECCION DEL EQUIPO PARA EL MONTAJE DE ARMADURAS Y ENTRAMADOS EN FABRICAS DE PEQUEÑA CONSTRUCCION INDUSTRIAL 1/

por

John R. Stokes, Director Gerente de la
Automated Building Components (Australia) Pty. Limited
Springvale (Victoria, Australia)

RESUMEN

Si bien la variedad del equipo existente para trabajos de construcción de cerchas es inmensa, sólo la prensa de chorote y la prensa de abrazadera en C equilibrada son adecuadas para la unión de maderas duras durante las primeras fases de la industrialización de un país en desarrollo.

Además, si se opta por la prensa de abrazadera en C equilibrada, ésta ha de ser del tonelaje suficiente para clavar a fondo los elementos de conexión y tener la rigidez suficiente para que la placa no se vuelva.

A este respecto, si se piensa adquirir este tipo de prensa, conviene enviar al fabricante muestras de maderas duras locales, en la cantidad suficiente para hacer por lo menos tres cerchas completas. El equipo y las piezas de conexión por que se opte podrán luego usarse para fabricar las cerchas.

La experiencia ha demostrado que a cada lado de una unión sólo puede aplicarse un elemento de conexión cada vez, pues si se intenta seguir la práctica comercial normal de aplicar placas en ambos lados a la vez, las placas se vuelven.

Se recomienda que estos trabajos experimentales sean supervisados por un ingeniero experto, especializado en madera de construcción, en representación del comprador.

En la monografía que aquí se resume no se trata la cuestión del equipo de aserrado. Cabe señalar, no obstante, que, para las plantas de construcción de cerchas bastante rudimentarias que se recomendaron, basta disponer 2 sierras Unipoint en un banco de tronzar, con una separación de 3 metros, para lograr producciones de hasta 100 cerchas por cada turno de trabajo de 8 horas.

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1/ Las opiniones que el autor expresa en este documento no reflejan necesariamente las de la Secretaría de la ONUDI. La presente versión española es traducción de un texto no revisado.

CONTENTS

# SELECTION OF EQUIPMENT FOR ASSEMBLING WOOD STRUCTURES AND FRAMES USING METAL CONNECTORS

## I. What is a Metal Connector?

1 In general this paper refers to spiked metal connector plates in which spikes or claws have been stamped from the parent plate in such a fashion that they protrude at right angles or thereabouts from the parent plate whilst remaining attached thereto. The teeth in general fall into two families which are:-

### The Nail Type

2 Having parallel-sided teeth in a regular pattern designed to optimise shear transfer and at the same time optimise the net section of the plate. E.g. Gang Nail, Hydro-Air, Dicker "Free Span", see illustration 1.

### The Plug or Flower Type

Having a series of claw like teeth (from two to five teeth) stamped to leave a flower like hole in the parent plate. E.g. Harvey Twin-a-plate, Sanford Connector, Bowman Connector, Bevaplate, Trans-Canada, Rigilok, Gismo, Ronel, Wood Claw, see illustration 1.

## II. In What Materials are Spiked Metal Connector Plates Used in Developing Countries?

3 Most of the Connector Systems have been designed in the Northern Hemisphere and hence have centred around the jointing of softwoods. This has had the effect of leading the bulk of the Connector system manufacturers into producing Connectors suitable for softwoods but unsuitable for use in tropical hardwoods, which are in most instances the main woods available for construction in the developing countries.

4 This unsuitability rests on questions of tooth length and hence column strength of the tooth, tooth spacing which affects wood splitting and net section of the parent plate, and the tensile strength, hardness and stiffness of the steel from which the Connectors are made.

5 In general Connectors for use in tropical hardwoods should be made from heavily galvanised semi-high tensile steel and should have parallel-sided teeth spaced at such centres that splitting does not occur, and with a relatively short tooth length to have adequate column strength, thereby ensuring that the tooth does not turn over or buckle when being pressed into the wood.

6 At the same time the teeth should be so spaced that the high shear transfer possible with hardwoods is matched by the residual net section of the Connector plate in the various directions which loads can be applied.

7 Heavy galvanising is necessary for Connectors used in tropical hardwoods because the wood is generally used either in the green state or after creosote or copper chrome arsenate pressure treatment.

8 In the case of green hardwoods attack by acetic and other acids present must be prevented by heavy galvanising. In the case of C.C.A. treatment the wood must be dried after treatment and heavy galvanising is still vital to prevent attack by leaching of minor residues of non-fixed salts. It should be noted that reductions in allowable tooth loads must apply with either C.C.A. or creosoted wood.

## III. From What Type of Metal Are Connectors Made?

9 As outlined above most developing countries use tropical hardwoods - either green or C.C.A. treated and re-dried. Hence the Connectors must be made from medium-high tensile steel heavily hot-dip galvanised with a coating of 2 oz. per square foot of zinc.

10 Alternatively, Connectors for use in hardwoods can be made from stainless steel and certain high-tensile aluminium alloys. The stainless steel connectors have a particular use in acid or harsh environments such as fertiliser works, fish canneries, salt works and cooling towers where normal galvanising is not adequate.

## IV. What Are the Main Uses of Spiked Metal Connector Plates?

11 The principal use of spiked metal Connector plates is in the fabrication of lightweight wooden trusses in spans from 15 feet to 60 feet.

12 In the developing countries it is frequently economic to fabricate gang nail type trusses in spans of up to 90 feet for light industrial buildings, schools, hospitals and rural buildings.

13 In most developing countries which import the bulk of their steel such trusses can be made at about half of the cost of a steel truss of equal load bearing capacity.

14 Additionally, the use of this indigenous renewable resource is most helpful in reducing balance of payment problems.

15 However, the prime use of such trusses is in the field of low-cost mass housing such as the National Housing Corporation's activities in the Philippines and the Sungei Way Project in Malaysia.

16 Additionally, the Ohbayashi-Gumi housing plant in Japan has a similar installation for the mass production of small house trusses.

17 Unlike the finger-joint which requires wood to be kiln dried to carefully controlled limits, spiked metal plate trusses can be readily made from green lumber which, of course, is a great advantage in low-cost mass housing programmes.

18 Secondary uses of spiked metal Connectors are:

(a) Jointing of wall panels and stud walls

(b) Pallet manufacture

(c) Furniture manufacture

(d) Case and crate manufacture

(e) The splicing of joists, beams and purlins.

## V. What Are the Normal Methods of Applying Spiked Metal Connectors?

19 In softwoods Connectors can be rolled on using a variety of proprietary machines (see Figures 2 - 9). Difficulties are nearly always experienced if rolling is attempted with hardwoods.

20 Alternatively, all types of Connectors can be better applied to softwoods or hardwoods using hydraulic presses which press the plates straight home.

21 This method is always more desirable than rolling because of the absence of the translatory tangential forces associated with rolling which tend to overturn the teeth and to crowd them in one direction. It can be noted that a flat platen equates to a roll of infinite diameter and obviously the bigger the roll diameter, the better.

22 Additionally, auxiliary nailing is often or usually necessary with the rolling process to enable handling of the "laid-up" truss from the fabricating deck into the rolling machine and frequently plates can only be rolled on to one side of the truss at a time.

23 The net result is a somewhat higher labour content in a roll-applied truss than for the direct hydraulic pressed truss.

24 A third option exists which has probably the greatest potential for the manufacture of trusses using green or dry tropical or temperate hardwoods in developing countries.

25 (a) This is the use of the air-operated impact press developed especially as a low-cost machine for the application of toothed type Connectors into either green or dry hardwoods and softwoods. (Fig. 2)

26 Essentially this machine consists of a manually propelled gantry frame of about 5 metres span which traverses on a pair of rails over a concrete deck approximately 5 m 50 cm x 15 m long, which deck is steel or bamboo reinforced and is approximately 20 cm thick.

27 A replaceable softwood grid is let into the surface of the slab and finishes flush with the surface. Blocks nailed to this are used as a means of clamping the truss profile accurately prior to jointing.

28 Mounted on the gantry using a ball bearing trolley is a readily manually moveable circular 550 kg steel hammer approximately 50 cm in diameter which can be lifted to a height of 75 cm clear of the deck by air pressure operating within an appropriate air cylinder, the piston rod of which is attached through a flexible joint to the hammer head. Oil and metal stampings or pellets weighing approximately 250 kg make the hammer head weigh up to 800 kg and dampen any tendency to bounce. A dumping valve enables the hammer to fall with very low friction losses and Connectors suitable for heel joints on trusses of 8 metres span can be impacted home with one blow. Larger Connectors can be driven home with 2 or 3 blows.

29 This machine is ideal for use in remote areas and on reasonably small projects in the developing nations because power can be provided by a small portable air compressor with a 3HP air-cooled petrol motor or a 3HP electric motor belt driving a 7 cubic feet per minute of Free Air Delivered (F.A.D.) capacity air-cooled compressor.

30 Such a compressor generally sits on a pad on top of an air receiver of 8 to 10 cubic feet actual volume, and the motor also sitting on slide rails on top of the receiver drives the compressor through a pair of light-section vee belts.

31 A receiver of this small volume does not usually require a Certificate from the Boiler and Pressure Vessel Inspection Authority, and can be regarded as virtually maintenance free.

32 Normally this Australian-designed Air Impact Press is made in the developing countries on the following basis:

33 (i) The fabricated steel gantry is welded locally using wheels, axles and bearings either procured locally or supplied by the designers of the machine.

34 (ii) The Air Ram and valves are imported from Australia or any other favoured nation.

35 (iii) The Air Compressor is generally readily available locally for around $U.S.375 including a 4-cycle air-cooled petrol motor.

36 (iv) The concrete slab is poured on a convenient location adjacent to the proposed new township. It is in fact sometimes poured in such a location that it becomes a part of the floor of a future school hall or shopping centre.

37 Using this equipment a truss plant capable of producing 80 trusses per day can be installed for a total cost of under $U.S.2750. Such equipment requires 2 unskilled workers and one man with carpentry skills operating the press line for the above production in 8 hours.

38 It is interesting to note that impacted Connectors generally give superior test results to hydraulically pressed joints which in turn are superior to rolled joints.

39 Additionally the height of dropping is infinitely variable from 0 to 30" (0 to 75 cm) thereby enabling the correct blow to be applied to joints large and small. No problem of Connector turnover is experienced with this type of press.

40 Costs of roller presses are similar to the impact press costs but jigs and fixtures and turning devices are required additionally, and electric power is normally required because of the torque requirements and shock loads implicit in this type of equipment.

The all up minimum cost of such an installation available from the U.S.A. or Europe is approximately $U.S.7000.

41 So far as hydraulic presses are concerned three main types are available. These are:

42 (i) The suspended counterbalanced C clamp type of press which is moved around the clamped truss members which rest on a series of fabricated stands or stations about 75 cm high. (Fig. 5)

43 The Connectors are applied to each side of each joint and held in place by a spring clip before pressing. Such a machine is also capable of about 80 trusses per 8 hours with 3 operatives as applies with the Impact press. The F.O.B. price being about $U.S.8000, is a little nigher than the Roller press with its auxiliary equipment. However, this press tends to be unstable with a strong tendency to turn over the teeth of Connectors in hardwoods samples of local hardwoods should be tested with the proposed Connectors before making any purchase of equipment.

44 (ii) The next type of hydraulic press is the Moving press, of which a number of differing types are made in the U.S.A.

45 In the types illustrated in Figures 6 - 8 a stationary jig with clamps securely locks the pre-cut truss members in place with the Connectors resting in place above and below each joint. The press then moves along the jig pressing each joint home, one or more at a time as it progresses.

46 Such a press is easily programmed for fully automatic action and can readily press 180 trusses per 8 hour day with 3 operatives. Additionally it has sufficient tonnage to apply Connectors into hardwoods.

47 The cost of this press which does not require any special foundations other than a normal 10 cm thick level concrete floor is about $U.S.12000 F.O.B. U.S. port.

48 Machines of this type have been installed in mass housing component factories in the Philippines, Japan, U.S.A., and Europe, and operate most satisfactorily.

49 However, they may perhaps be too sophisticated for the bulk of the developing nations and do not lend themselves to local manufacture in many areas.

50 (iii) The third type of hydraulic press available is a static unit patented in the U.S.A. and made in that country. This more expensive piece of equipment will apply Connectors into any hardwood. (Fig. 9)

51 A moving jig generally 30 to 80 feet long by 7 to 10 feet (2.1 m to 3 m) wide carries the pre-cut truss members clamped into their correct profile through the press opening.

52 Again the press can be automatically programmed and with 3 operators this machine can produce 300 trusses per 8 hour shift.

53 Again the equipment is not ideal for the developing countries but nevertheless machines of this type are operating successfully in a number of developing countries including Argentina, Malaysia and Vietnam.

54 Such a machine including a typical jig and jig hardware costs approximately $U.S.16000 F.O.B. The total installed power for such a plant is approximately 30HP and the equipment requires a reliable electrical supply. Whilst the equipment is sophisticated the same skills which service a modern hydraulic bulldozer can service the above machine.

55 A fourth type of hydraulic press has up to 12 heads which can either rock back or retract during the loading phase and unloading phase, and which simultaneously close and press all joints in a truss at the one time.

56 Such machines are capable of making about the same volume of trusses per shift as the moving jig type press with a similar labour force of 3 operators.

57 Because all joints are pressed simultaneously either power requirements are higher or the cycle is slower and such machines are generally unsuitable for hardwoods where forces of up to 50 tonnes per joint are frequently required.

58 However in the developing countries truss spans for housing are low at about 8 metres average and tonnage requirements here rarely exceed 35 tonnes.

59 However when industrial and agricultural trusses and trusses for school buildings and other similar structures are made in spans of up to 20 metres, the full 50 tonne capacity per head is definitely needed in all hydraulic press plants.

## VI. Conclusion and Summary

60 A wide range of truss fabricating equipment is available but of all that is available only the impact press and the counterbalanced C clamp type press are suitable for the jointing of hardwoods during the early phases of industrialisation in a developing country.

61 In addition, if used, the C type counterbalanced press must have sufficient tonnage to press the Connectors home, and must be of sufficient rigidity to prevent plate turnover.

62 In this regard if the purchase of this type of press is contemplated, samples of local hardwoods should be sent to the manufacturer in sufficient quantities to make at least 3 complete trusses. The favoured equipment and Connectors can then be used to attempt to make up the trusses.

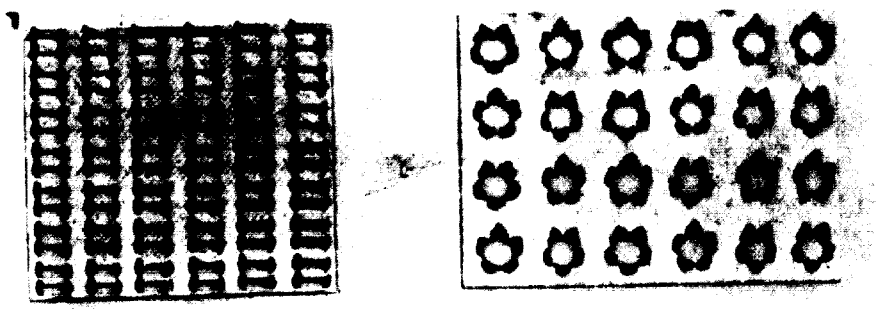
63 Experience has shown also that whereas one Connector can be applied to one side of a joint at a time that when the normal commercial practice of applying plates to both sides is attempted then turnover occurs.

64 It is recommended that this experimental work be supervised by an experienced Timber Engineer representing the purchaser.

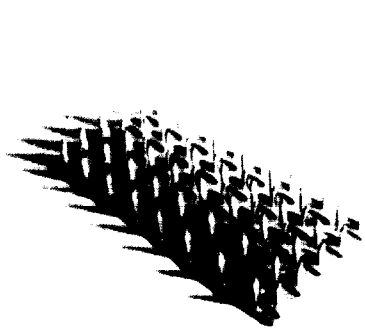
65 Sawing equipment has not been discussed in this paper However, for the rudimentary truss plants recommended above 2 UNIPOINT type pull saws set in a cutting bench approximately 3 metres apart will suffice for a production of up to 100 trusses per 8 hour shift. (See Figures 10 - 12)

66 A simple truss plant layout is appended. (Fig. 13)

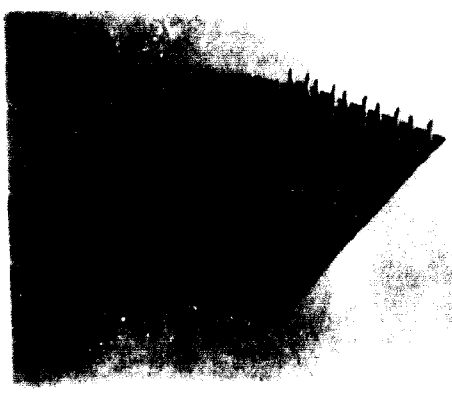
Figure 1



A. Toothed and Plug Type Connectors suitable for softwoods



B.



C.

Toothed semi high tensile heavily glavanized connectors suitable for hardwoods

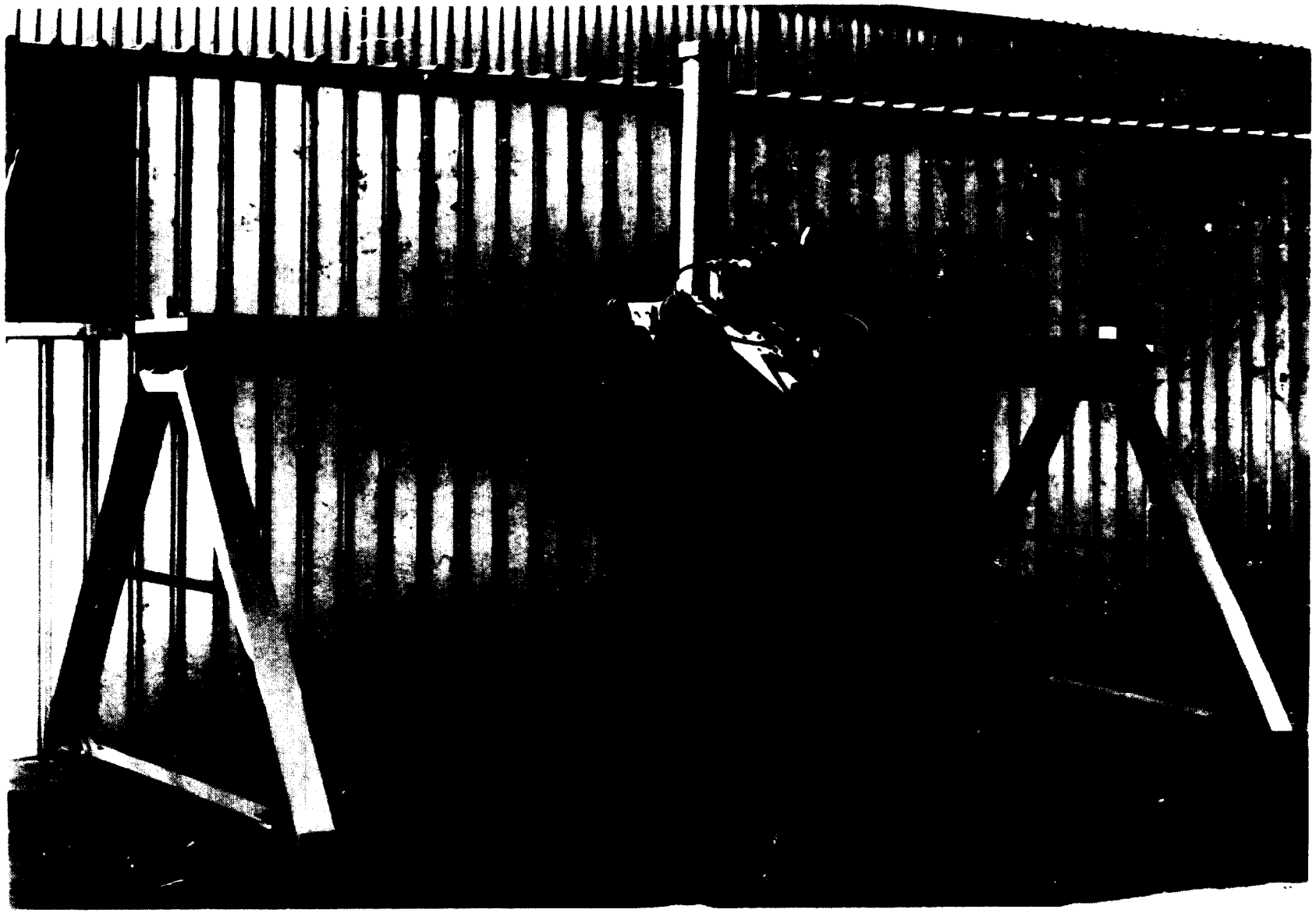


**Figure 2** Patented air operated impact press suitable for hardwoods and softwoods, which is powered by a 4 H.P. petrol-driven air compressor. GANG NAIL AUSTRALIA

# Roller Presses

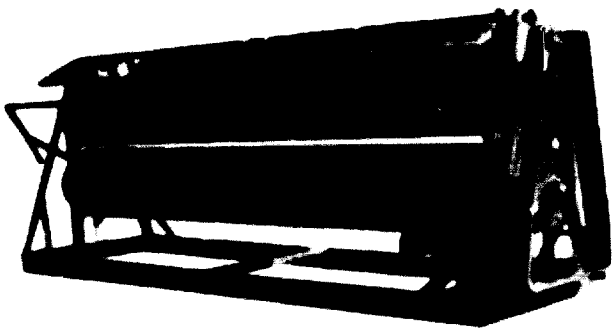


Figure 3

Roller press suitable for softwoods T.C.T. U.S.A.

Figure 4

High production roller press suitable for softwoods
Sanford U.S.A.

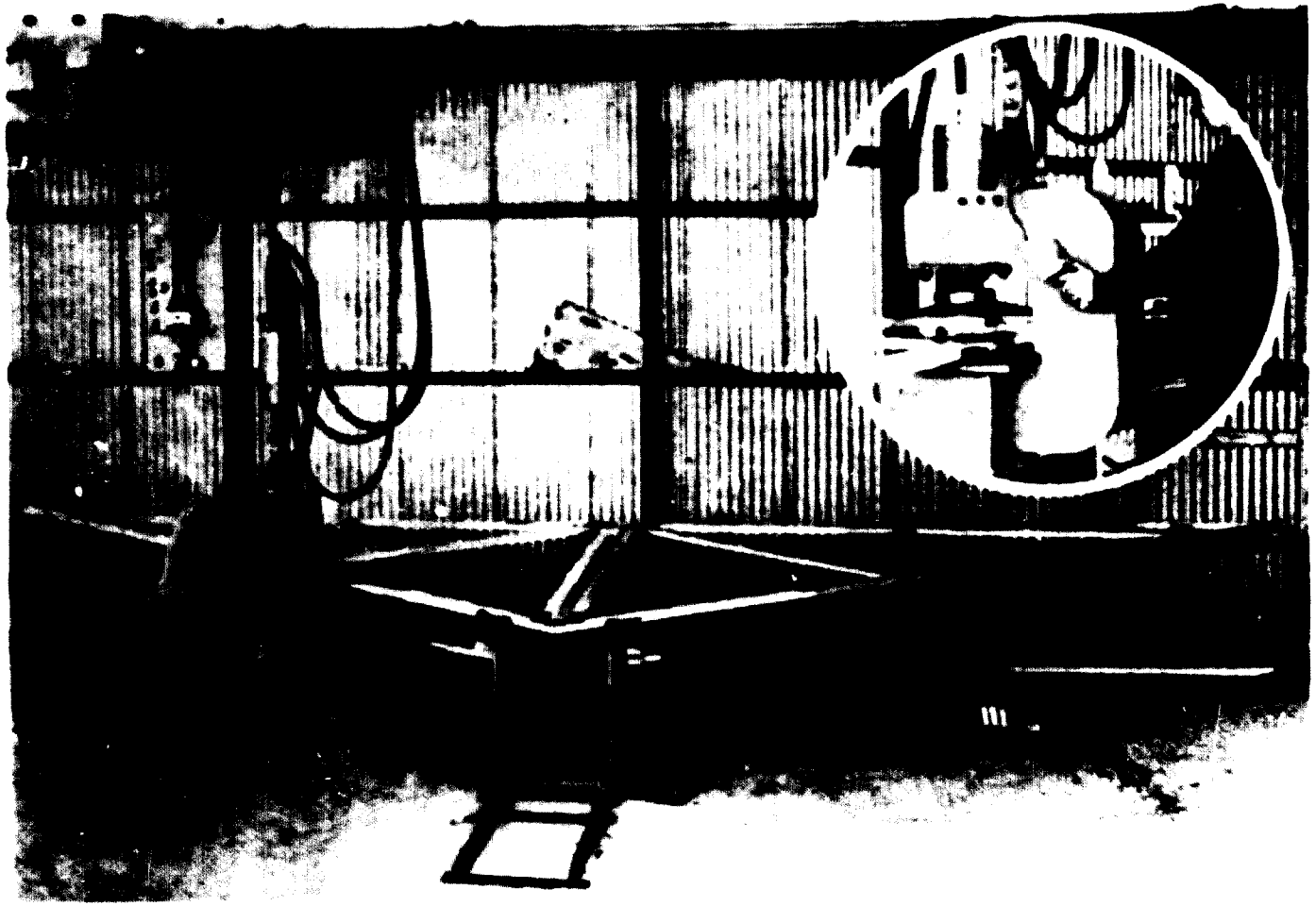
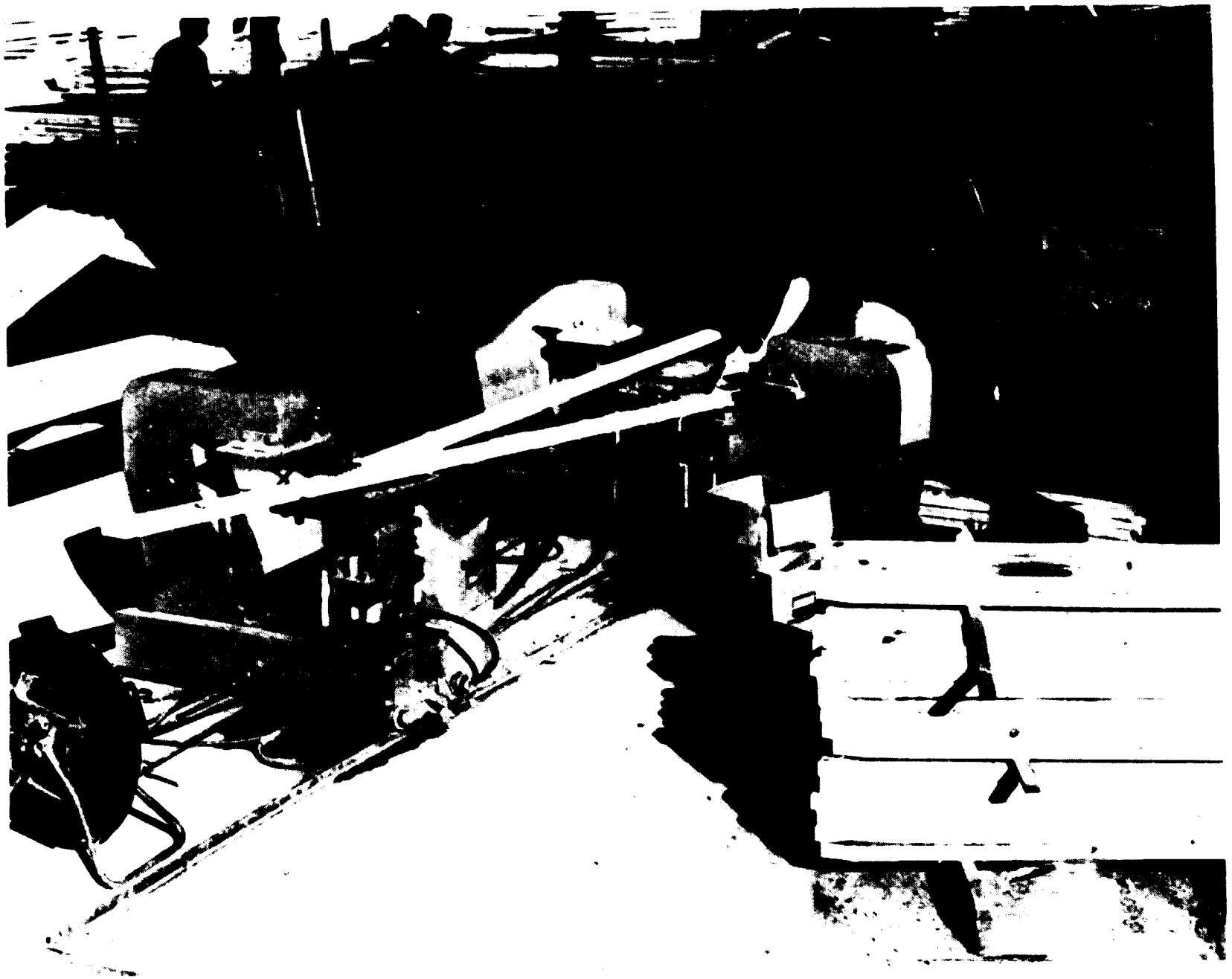


**Figure 5** Counter balanced C type press suitable for softwoods and in some cases hardwoods
BLOCK WATNE, NORWAY

Figure 6 General view of moving head press suitable for high production in softwoods IDACO U.S.A.



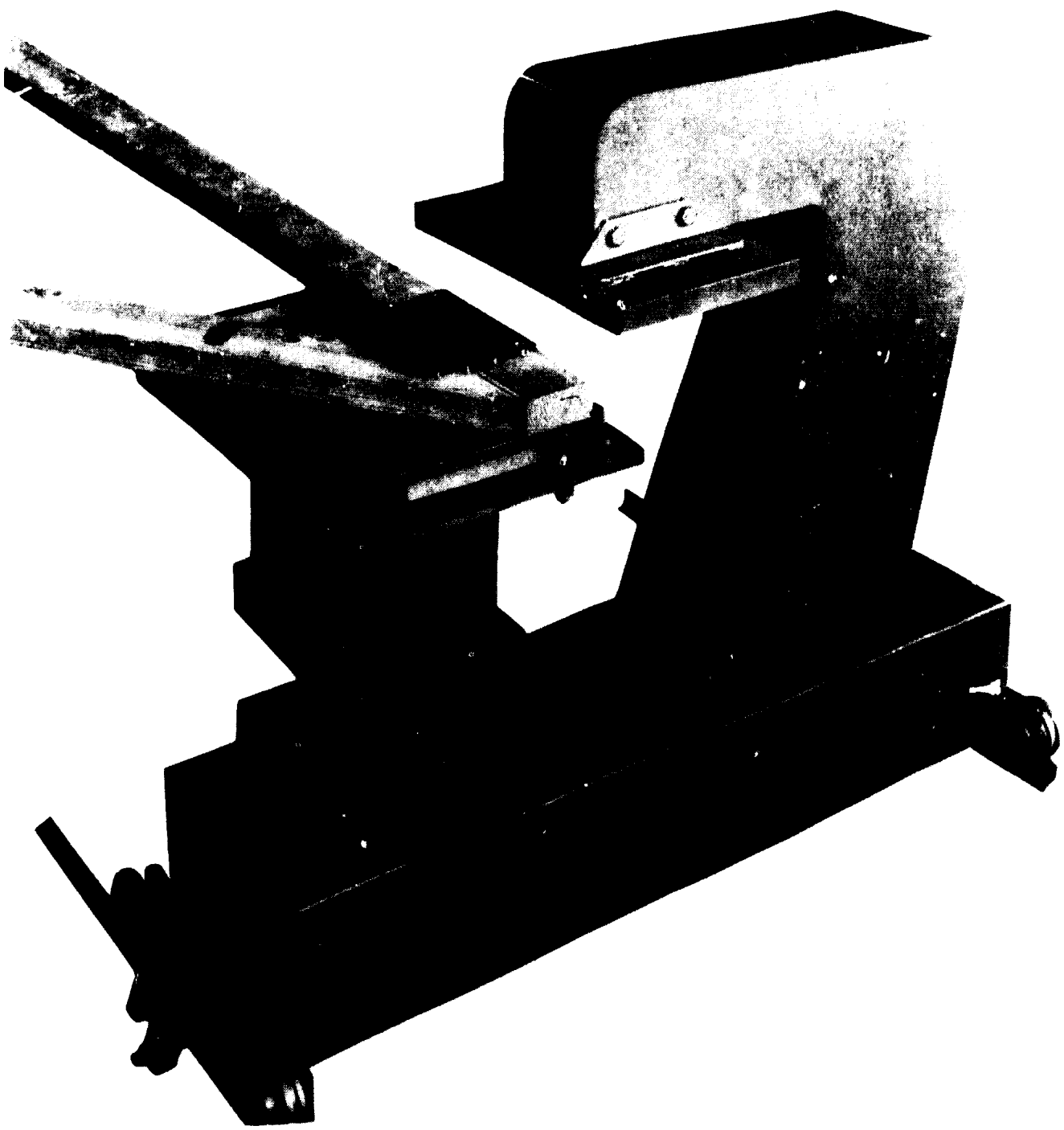


Figure 7

Moving head press suitable for high production in softwoods IDACO U.S.A.

Figure 8 Medium production moving press with static jig suitable for softwoods or hardwoods GANG NAIL U.S.A.

Figure 9 High production moving jig hydraulic press suitable for either softwoods or hardwoods. GANG NAIL

World wide manufactured in U.S.A., Canada, Australia and Europe

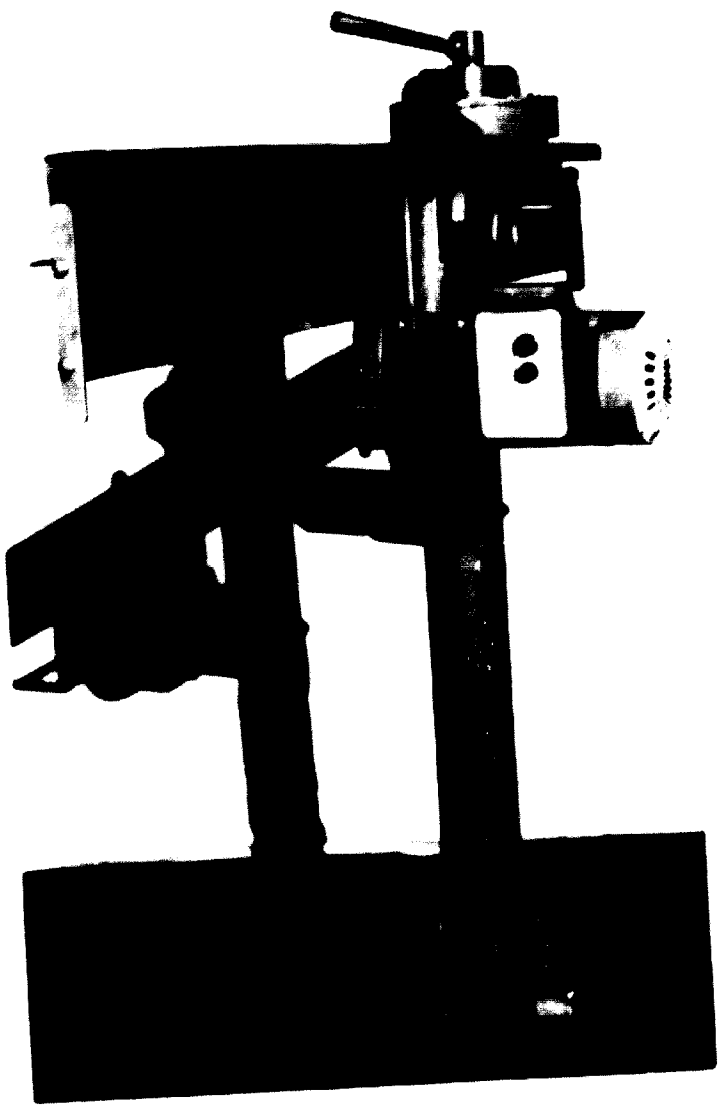


**Figure 10**

Simple uni-point type saw manufactured by Tate Bros., Western Australia for truss component cutting in the developing nations.

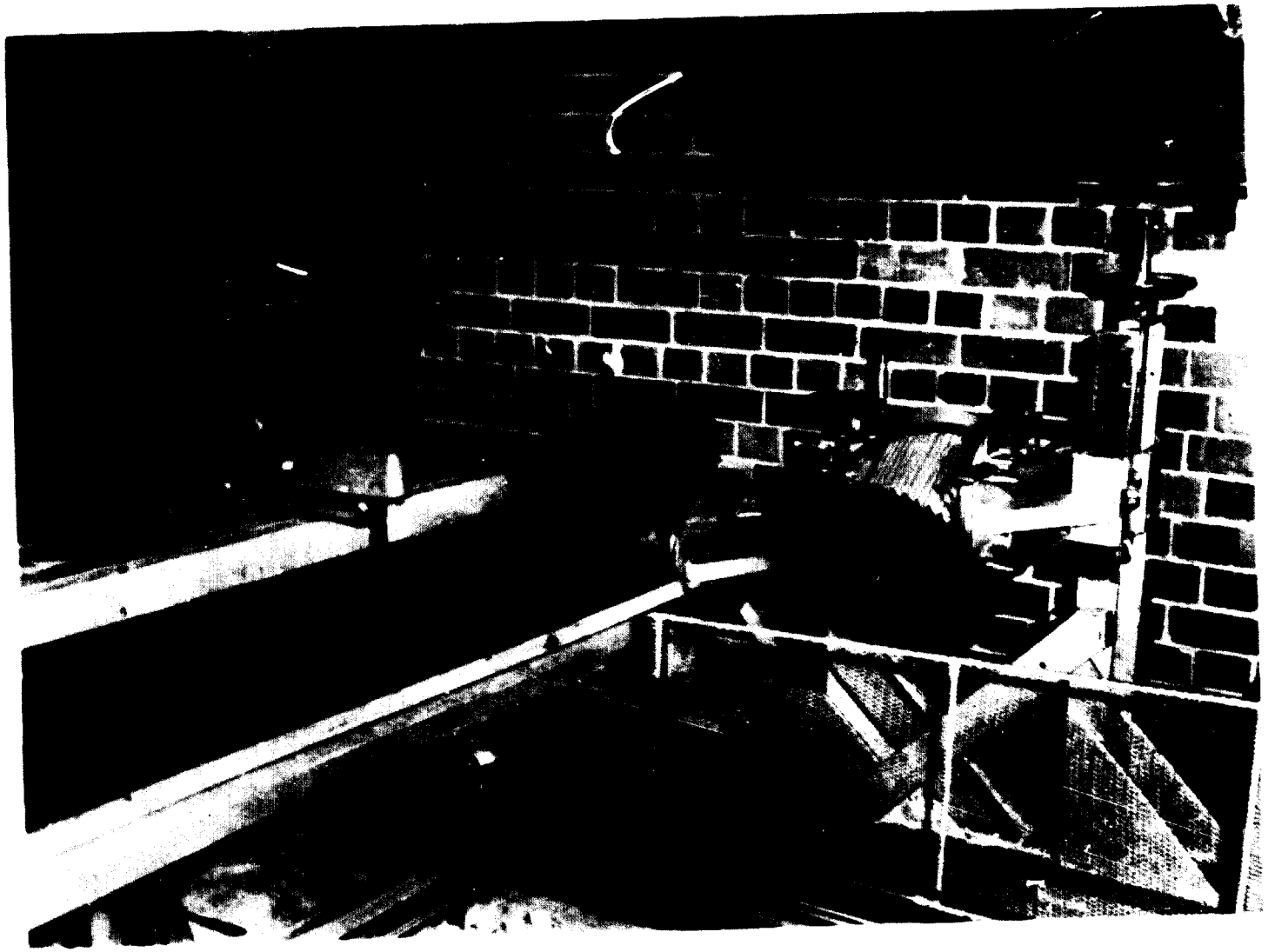


Figure 11

Simple hand fed double saw web cutter built in Africa. Note clamp holding multiple web members prior to cutting. This unit is suitable for softwoods and hardwoods and is fed by one operator.

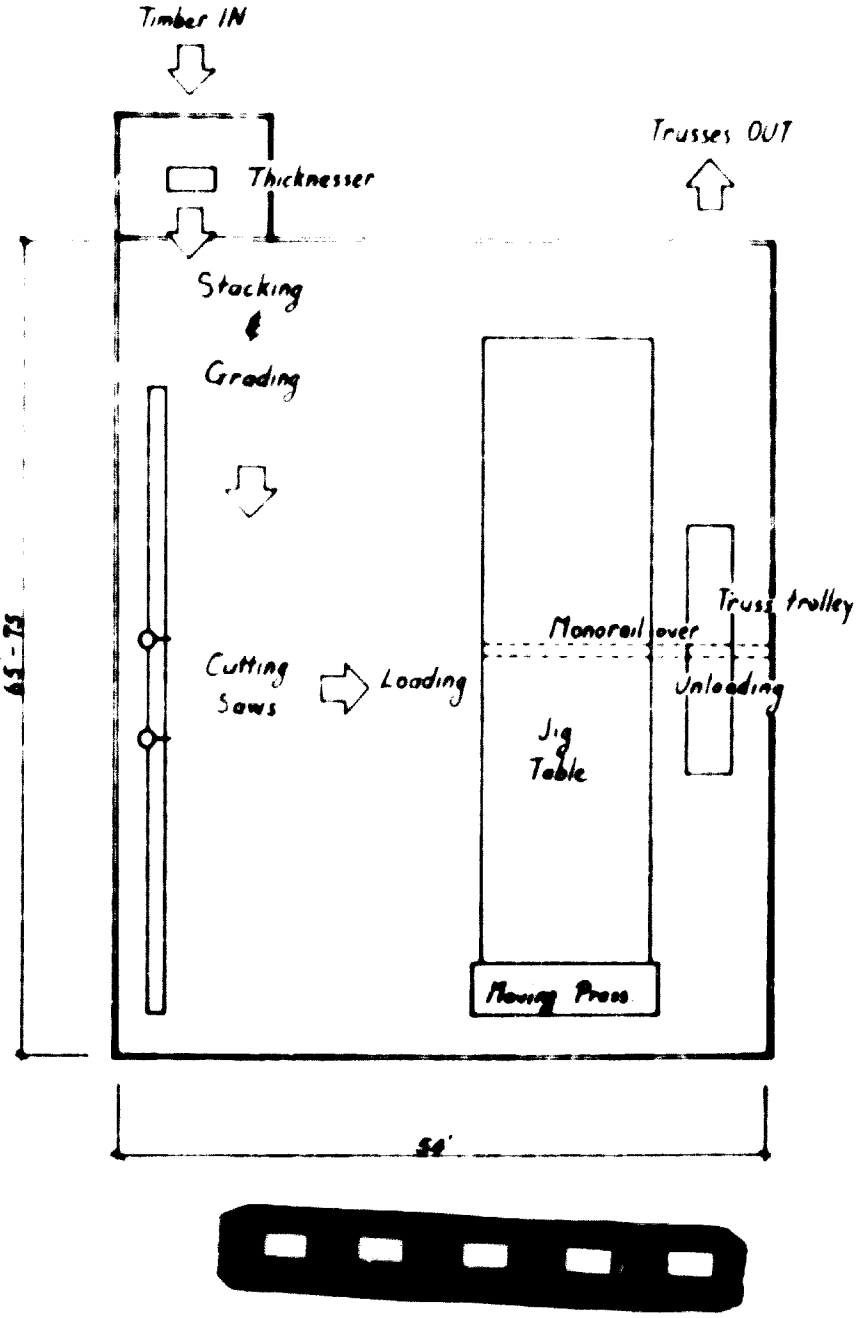
Figure 12

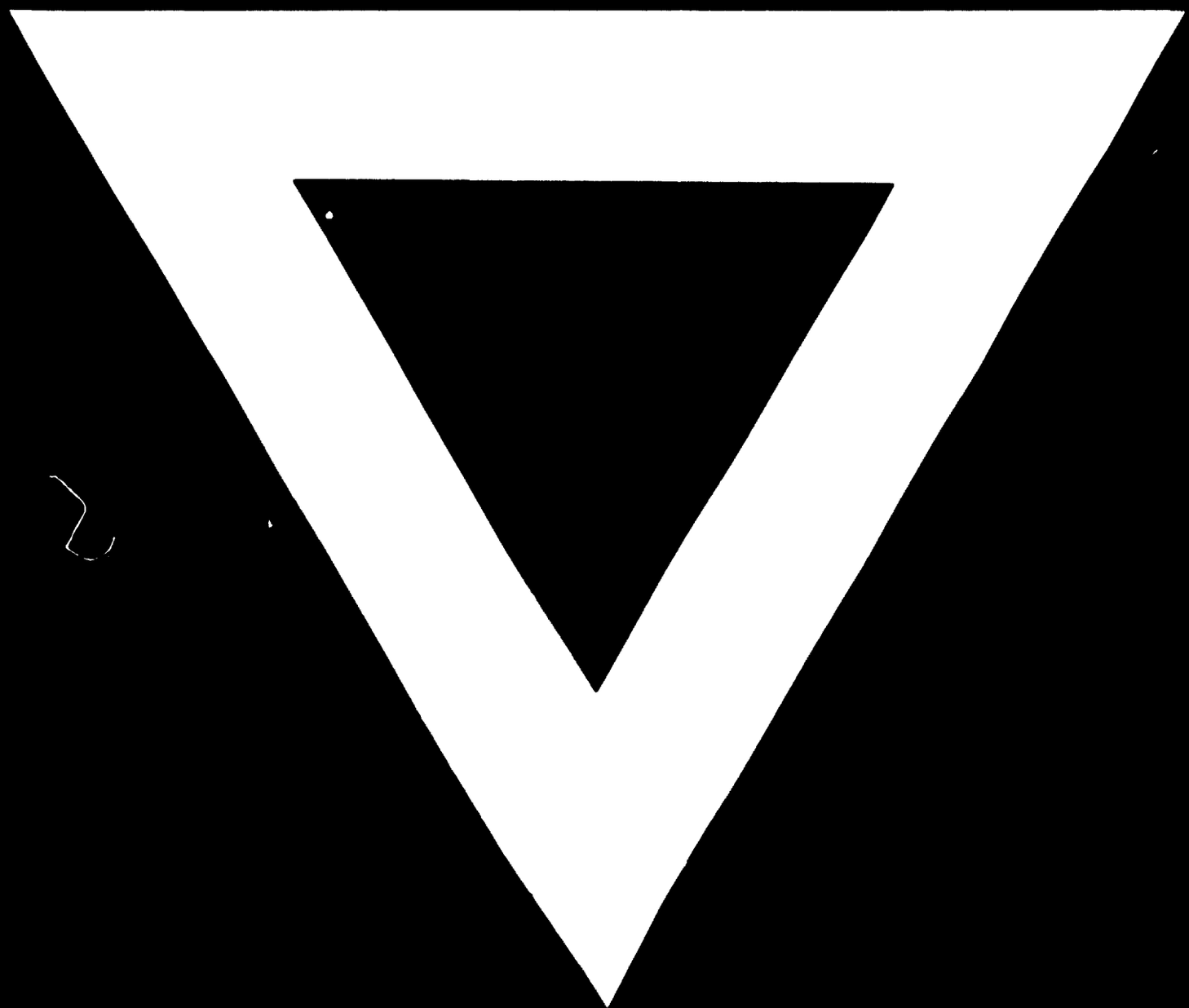
Closer view showing cutting action of the simple hand fed twin saw wet cutter.

Figure 13

Typical Truss Plant Layout

Moving Press





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