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05300

United Nations Industrial Development Organization

Distr.
LIMITED

ID/WG.151/18
3 October 1973

ORIGINAL: ENGLISH

Technical Meeting on the Selection of Woodworking Machinery

Vienna, 19-23 November 1973

SELECTION OF EQUIPMENT FOR JOINING[1/]

by

E. van der Straeten and J. Reinhardt
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United Kingdom

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id.73-6731

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SUMMARY

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id.73-6732

SUMMARY

Machines for glue joining boards are all of a specialised nature, but certain underlying requirements apply throughout. In the authors' experience inadequate attention is frequently paid to the fundamentals of the process which the machine has to accomplish. The first part of the paper, therefore, describes in detail the requirements for making satisfactory glue joints, irrespective of the equipment used. Some of these, moisture content, preparation of edges and treatment of the surfaces to be glued, lie outside the operations which are performed by all but the most complex joining machines. They are included, however, because it is considered that failure to observe good practice in these areas results in joint failures, which in turn are erroneously considered to be due to shortcomings of the equipment in use. It should also be appreciated that not all gluing and joining equipment can be used with more than one type of adhesive. Primarily, therefore, it is necessary to decide from the type of adhesive to be used and the other conditions contingent upon this choice before proceeding to the selection of a particular machine.

Having decided which type of glue is to be used, consideration may then be given to the merits and demerits of particular pieces of equipment. In certain areas of glue joining, e.g. veneer splicing, it is not uncommon to find that only one or two machines are available in a specific class. Although machine descriptions are general and manufacturers' names not mentioned, some of the descriptions given only apply to a single machine, which those familiar with the subject can doubtless identify.

Machines which utilise simple mechanisms and are intended for room-temperature setting glues, should not necessarily be considered inferior to the more complex types. Here the choice depends upon the output of finished components required.

Some joining machines, particularly edge banders, perform additional operations connected with the subsequent processing of the edged panel. In factories where high outputs are required, the inclusion of such equipment may be considered desirable but achieving well glued joints is not dependent upon such optional attachments.

Other processes considered, e.g. veneer splicing and solid wood end-joining, are only carried out where a high degree of quantity production is already established. All the machines described are thus fairly complex with corresponding demands on skilled personnel for initial setting up and maintenance. In other processes, however, e.g. solid wood edge joining, squaring up and to some extent edge lipping, very simple methods may be employed, with quite satisfactory results.

Where high outputs are required, it is invariably necessary to accelerate the setting of the glue by the application of heat. Frequent mention is made of RF and low voltage heating methods in this context and so a general description of these processes with a brief theoretical background is given (Processes iv).

In compiling the bibliography, no attempt has been made to refer to detailed publications supporting the main points made in the paper. The books included, however, will provide a broad background to the whole topic, the titles indicating roughly the aspects of the subject of joining timber to which they are most directly related. The whole topic of joining machines is so specialised that it has been difficult to find published information describing the types of machine available in detail, other than the descriptive literature of various machine manufacturers.

It is hoped that the discussion of the various principles and requirements of joining processes given in our paper will enable the machine manufacturers' information to be more clearly understood and, where necessary, compared closely with alternatives offered by other manufacturers, thus enabling selection of the best machine for the individual users requirements.

Distr. LIMITEE
ID/WG.151/18 RESUME
3 octobre 1973
FRANCAIS
Original : ANGLAIS

Organisation des Nations Unies pour le développement industriel

Réunion technique sur le choix des machines dans l'industrie du bois

Vienne, 19-23 novembre 1973

RESUME

COMMENT CHOISIR LES MACHINES A ASSEMBLER[1]

par
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Toutes les machines à assembler par collage sont spécialisées, mais elles ont en commun certaines caractéristiques fondamentales. Les auteurs estiment qu'on n'accorde pas assez d'attention aux mécanismes des opérations essentielles que la machine doit accomplir. Dans la première partie de leur document ils exposent en détail les opérations à accomplir pour fabriquer des assemblages collés satisfaisants, quel que soit le matériel utilisé. Certaines opérations comme le dosage de l'humidité, la préparation des chants et le traitement des surfaces à coller ne peuvent être accomplies que par les machines les plus perfectionnées. Toutefois, les auteurs en donnent une description car ils jugent que si l'on n'observe pas les règles de l'art, on obtient des assemblages défectueux qui sont eux imputés à tort aux insuffisances du matériel. Il faut également se rendre compte que toutes les machines de collage et d'assemblage ne peuvent pas être utilisées avec plus d'un type d'adhésif. Il faut donc décider d'abord du genre de colle à utiliser et déterminer les autres conditions qui découlent de ce choix avant de sélectionner l'une ou l'autre machine.

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

id.73-6733

Le type de colle étant choisi, on examinera alors les avantages et les inconvénients respectifs des différents matériels. Pour certaines opérations d'assemblage par collage (le jointage des placages, par exemple) on constate assez souvent qu'il existe une ou deux machines seulement dans chaque catégorie. Bien que les descriptions de matériel aient un caractère général et que les noms des fabricants ne soient pas indiqués, certaines descriptions ne peuvent s'appliquer qu'à une seule machine que les techniciens identifieront sans difficulté.

Les machines au fonctionnement simple prévues pour que la colle prenne à la température ambiante ne doivent pas être systématiquement considérées comme inférieures aux modèles plus perfectionnés. En l'occurrence, le choix dépend du volume de production à atteindre.

Certaines machines à assembler, notamment les machines à coller les placages sur chants, permettent en outre certaines opérations d'usinage des panneaux collés sur chants. Les usines où des productions élevées s'imposent jugeront peut-être que ces équipements sont souhaitables, mais la fabrication d'assemblages bien collés n'en dépend pas.

Les auteurs passent en revue d'autres opérations comme le jointage des placages et l'assemblage en bouts de pièces en bois massif qui ne sont entreprises que lorsque le volume de la production a déjà atteint un niveau élevé. Toutes les machines décrites sont assez complexes et exigent donc un personnel spécialisé, tant pour le démarrage que pour l'entretien. Toutefois, pour d'autres opérations comme l'assemblage sur chants de pièces en bois massif, l'assemblage d'angles et, dans une certaine mesure, le collage des placages sur chants, on peut obtenir des résultats fort satisfaisants avec des méthodes très simples.

Pour obtenir des productions élevées, il est toujours nécessaire d'accélérer la prise de la colle par des procédés thermiques, les techniques de chauffage à haute fréquence ou à basse tension étant fort souvent citées à ce sujet. Le document comprend une description générale de ces techniques complétée par un bref exposé théorique (Procédés, iv).

Dans la bibliographie, les auteurs n'ont pas cherché à inclure des publications appuyant les arguments qu'ils développent. Toutefois les ouvrages qui y sont cités donneront un aperçu général de la question, les titres indiquant en gros les différents aspects de l'assemblage dont ils traitent plus particulièrement. La question des machines à assembler est si spécialisée qu'il est difficile de trouver des publications détaillées sur les différents modèles de machines, hormis les notices descriptives publiées par les fabricants.

Les auteurs espèrent que l'exposé des principes et des techniques d'assemblage fait dans ce document permettra aux utilisateurs de mieux comprendre les informations fournies par les fabricants de machines et de sélectionner la machine la mieux adaptée à leurs besoins, après avoir comparé, au besoin, ces informations avec celles que donnent d'autres fabricants.

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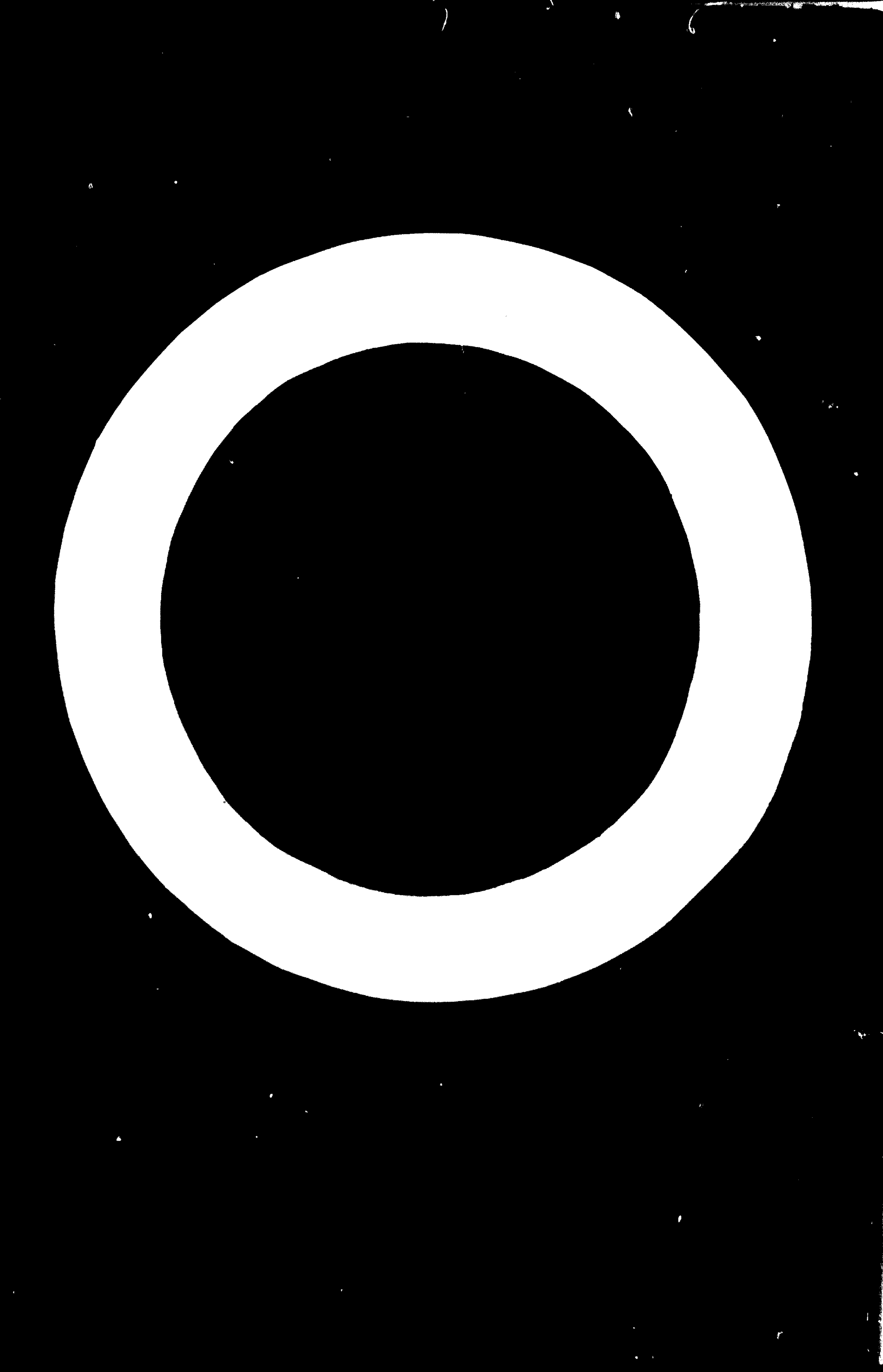

SELECTION OF EQUIPMENT FOR JOINING

I INTRODUCTION - FUNDAMENTALS OF JOINING

1. Unlike many metals and plastics materials, timber is available only in pieces of limited length, width and thickness, the last two dimensions being particularly restricted. The majority of manufactured wooden articles, furniture, building components and so on, require the raw materials to be joined to increase their cross-section and, less commonly, their length.

2. The increasing scarcity of timber of good quality and appearance has accelerated the development and application of wood-based sheet materials. Whilst these materials to some extent overcome problems of obtaining timber in adequate widths, and are structurally equivalent, and sometimes superior, to natural wood boards, they are seldom as visually attractive. For this reason sheet materials must be surfaced, often with veneers of expensive hardwood species, and this provides a further need for the joining of timber surfaces.

3. Traditionally, timber was joined by mechanical means where the finished article was required to have substantial strength, for example in building construction and in the manufacture of tables and chairs. The joining of timbers edge-to-edge to increase their width, and the application of fine species to the surfaces of poorer quality materials, however, has always been accomplished by gluing. To-day, with the development of the wide range of modern glues, gluing is by far the most common means of securing pieces of timber together. Gluing has the advantages of making joints which are not easily detected; of efficiently transmitting stress from one component of a structure to another, such as in glued roof trusses and laminated timber beams or columns; and, perhaps most importantly, of enabling the width, thickness and length to be increased whilst allowing the finished article to be processed, sawn and shaped as though it were a single piece of wood. For large industrial production of wooden articles, machines have been developed to accomplish these joining operations rapidly and efficiently. Surfaces are prepared, adhesives applied and joints assembled and held in

place whilst the adhesive is cured, on single machines. Hardening of the adhesive is frequently achieved in a very short time by the application of heat, either directly or by such techniques as radio-frequency heating.

4. This paper discusses the principles, merits and disadvantages of individual machines performing the various categories of joining processes. Although mention has been made of complex machines, performing a variety of processes in sequence, these are only justified where high output of finished components is required. All joining processes are considered from the simplest hand clamps upward. It should be appreciated, that the strength and quality of joints made on complex machines is not necessarily superior to those made with simpler equipment; the important criterion is that the whole joining process should be aimed at attaining the conditions of surface quality, moisture content, temperature and so on, required by the particular adhesive used. Before going on to discuss joining machines, therefore, the characteristics of adhesives and the requirements of gluing processes are discussed; since a fair understanding of these, and the application of this knowledge, must be one of the factors which determines choice of a particular machine.

(i) Adhesives - Main Types and their Characteristics

5. Adhesives may be divided into two groups according to their origin:

a) Natural products
b) Synthetic products.

For wood gluing the latter may be further sub-divided into adhesives based on:

- Thermosetting materials
- Thermoplastics materials.

Adhesives based on natural materials are derived mainly from the following:

- Gelatine
- Casein
- Soya beans.

6. All are proteins and form viscous dispersions in water, after suitable formulation, which, when dried, form tough films that adhere well to cellulosic materials.

7. Compared with synthetic materials, natural glues are simple to use but tend to be slower to set, and are particularly slow to develop their final strength. They are all more or less sensitive to moisture, which has the effect of softening the adhesive and drastically reducing joint strength. Moreover, protein is particularly vulnerable to attack by micro-organisms, such as fungi. These two properties are serious drawbacks, especially in tropical climates. Limited durability and relatively slow setting characteristics have thus led to their extensive replacement, in industrial operations, by synthetic adhesives. Also, the cost of natural adhesives, as with many other natural products, is tending to rise relative to entirely synthetic chemicals. This is a natural result of increasing scarcity, the use of non-traditional protein in foodstuffs, and the fact that the working-up of natural products to their final form is often a labour-intensive process.

Synthetic Adhesives - Thermosetting

8. The most commercially significant thermosetting wood adhesives are all based on condensation polymers of formaldehyde.

9. These are available in liquid or powder form. Both require to be mixed with a hardener (catalyst) before use. Powder resin may occasionally be supplied already blended with hardener. This blend is relatively inert, having a life of up to 1 year stored under cool, dry conditions.

10. When liquid resin (or reconstituted powder) plus hardener have been blended, the resultant mixture has a finite life (pot-life); this may vary from a few hours, to more than 24 hours, depending on the type of adhesive. As their name implies, setting of these materials may be accelerated by heat and many gluing processes utilise this fact to advantage. Materials which are sufficiently reactive to cure at room-temperature normally have a pot-life of only a few hours; the longer pot-life materials requiring an elevated temperature to cure them.

11. The resistance of thermosetting glues to water - particularly at elevated temperatures - and degradation by weathering, are greatly superior to those of natural adhesives. The durability of joints under severe climatic conditions varies with the chemical type of adhesive and these are considered in ascending order of durability below.

Urea-Formaldehyde (UF)

12. These are probably the most widely used thermosetting adhesives and are available in forms which cure at either room or elevated temperatures. For specialised processes, such as radio-frequency, their properties may be modified to increase still further their rate of setting. Further modifications to the mixed adhesive include incorporation of fillers to control flow or reduce glue-line costs, and for the edge joining of veneers, special lubricators which prevent the partly cured glue from adhering to the fixed parts of the machine (see Processes - i)a below). The cured adhesive is colourless.

Melamine Formaldehyde (MF)

13. Adhesives based on this material have considerable resistance to water and heat and are more weather resistant than UFs. They are expensive and used only in certain specialised processes. They have the advantage of producing an almost colourless glue-line c.f. PF and RF glues.

14. Combinations of UF and MF glues are also available for specialised uses. The introduction of UF resin reduces cost with corresponding reduction in durability under adverse conditions.

Phenol-Formaldehyde (PF) and Resorcinol-Formaldehyde (RF)

15. Although available for many years, these types are still the most durable wood adhesives.

16. The properties of PF and RF resins are in many ways similar, though RF resins are more reactive and may be cured at room-temperature. RF is, however, the most costly of the thermosetting group. PFs are mainly available as hot-setting plywood adhesives, room-temperature curing versions have been

produced but strong acids are required to cure them, presenting many handling difficulties. Cold-setting PFs are only soluble in alcohol. The hardened glues are red-brown to almost black.

Thermoplastics Adhesives

17. This group is most commonly based on polyvinyl acetate resins (PVAc). This type of adhesive requires no mixing with catalyst - though a sub-division of this group is developing in which a cross-linking agent is added just before use. These two-part formulations have improved resistance to heat and moisture and can be used in gluing processes where heat is applied to accelerate hardening. PVAc glues develop strength rapidly at room-temperature and adhere well to all cellulosic materials. Their resistance to elevated temperature and/or wet conditions is inferior to those of urea-formaldehyde glues. They are also excluded from some applications because the joints 'creep' under sustained loading.

18. Also included among the thermoplastics are hot-melt adhesives normally based on ethylene-PVAc copolymers. These are rubbery solids which melt at temperatures between 180-220°C. to become viscous liquids. Applied to one surface of a joint when molten, and brought quickly into contact with the opposite surface, a strong bond develops as the adhesive cools. This technique has enabled the development of specialised machines used mainly for edge lipping and banding (Processes - iv below) which are capable of forming glue bonds very rapidly. The joints made with hot-melts, however, are less resistant to water and heat than those made with thermosetting adhesives and at present their use is limited mainly to furniture applications.

19. Having considered the different properties of adhesives which may influence their selection for a particular application, it is useful to examine the conditions which affect their bond-strength. Assessing how well these requirements are met by a given piece of equipment, should be one of the factors influencing its selection or rejection for a particular purpose.

ii) Moisture Content of Timber

20. Wood moisture content can be decisive in determining the strength and durability of glued wood joints. Some of the more common mechanisms through which this influence is exerted are described below.

21. Glues which set purely by loss of water, rely on diffusion of water into the adjoining wood e.g.

- casein
- animal glue
- PVAc

22. An optimum moisture content range for gluing with these adhesives is 10-14%. At high moisture contents, the expected rate of hardening may be increased and at levels above 14% for PVAc and animal glue, and 16-18% for casein, a progressive increase in setting time is to be expected.

23. On the other hand, loss of water from the glue-line increases viscosity and helps to prevent glue being absorbed by the surrounding wood, which may otherwise lead to 'starved' joints. Excessively dry wood, below 5%, can also be over-absorbent, although this can sometimes be overcome by increasing glue spreads - see (iv) below. The absorption of moisture from the glue-line into excessively dry wood is accompanied by a rapid rise in viscosity of the glue film, which can reduce its ability to flow when the joint is finally assembled and under pressure, with a consequent reduction in wetting of the opposite face of the joint.

24. Similar considerations apply to thermosetting adhesives, although some of these are less sensitive to high wood moisture contents than others. Resorcinol-formaldehyde glues can be used on timber as high as 24% moisture content without seriously impairing the final joint strength. UF glue, on the other hand, should not be used on surfaces above 18% moisture content.

25. The foregoing considerations apply to gluing operations carried out at room-temperature, say up to 27°C. Under warm or hot pressing

conditions, particularly at temperatures above 100°C. further considerations apply.

26. Under hot pressing conditions, moisture tends to migrate from the surfaces in contact with the press platens toward the glue-line. This can cause excessive dilution of the glue. Moreover, the rate of the chemical reaction, which brings about setting, is considerably influenced by the solids content of the adhesive film; dilution of the glue film under such conditions can drastically increase setting rate. In severe cases, the water is super-heated, this boils instantaneously when pressure is released, resulting in steam formation and complete rupture of the bond. Where the temperature in the glue-line is likely to exceed 105-110°C. it is desirable to limit the moisture content of the materials to 12%.

27. Where radio-frequency curing methods are used, moisture in the wood can increase its 'loss' factor allowing power to be dissipated through the timber at the expense of the adhesive. Here too, prolonged setting can often result in bond failure.

(iii) Surface Preparation

28. Good joints in wood can only be obtained when joint faces are smooth, accurately cut and free from surface contaminants, particularly oily substances.

29. Although some adhesives are strong in fairly thick films (0.5-1.5 mm) others are less tolerant of uneven surfaces. Natural adhesives and PVAc generally contain 50-70% of water giving rise to considerable shrinkage of the glue film when dry, although this can be reduced by careful formulation. Synthetic glues, except those used for hot press plywood manufacture, normally contain only 30-40% of water, with consequently less shrinkage on hardening. Glues which are capable of giving strong bonds with thick glue-lines are normally described as 'gap-filling'. In general, the thinner the glue-line the higher the bond strength.

30. If the surfaces to be bonded are not parallel and in the same plane, bonding pressure will have to distort the components before the two surfaces make adequate contact. Joining machines should therefore be selected to give a sufficient pressure for the type of work contemplated but should not be expected to correct inaccurate preparation of the components.

31. Surface texture is also important. Solid timber is normally prepared for gluing by machines with rotary cutter heads, exerting a planing action. This can, however, give rise to burnishing the surface which reduces wetting by the adhesive. Fine sawing can often produce a better bonding surface with cleanly cut wood cells which are ideal for adhesive wetting.

32. The age of the surface also influences bond strength. It has been shown that certain wood extractives, which are hydrophobic, migrate to wood surfaces after machining has been carried out, and surfaces prepared some time before gluing do not bond satisfactorily. This is quite independent of any distortion which may take place due to changes in moisture content during storage.

33. It should not be overlooked that certain preservative treatments can also influence the gluing properties of prepared surfaces.

(iv) Applying Adhesives

34. Provided that an even film of the recommended coating weight is applied, the method is determined mainly by the output required.

35. Simple application by brush or scraper is quite adequate for hand work, although if large areas or a great number of components per hour are to be spread, some form of mechanical applicator will be necessary. As many joining machines incorporate glue applicators, their suitability to the chosen type of adhesive should be considered during selection. Thermosetting adhesives with limited pot-life dictate that the applicator should be readily removed and stripped for cleaning; preferably the quantity of glue required to maintain an adequate spread should be small, to reduce the time that the mixed adhesive remains in the glue reservoir.

36. Hot-melt adhesives and animal glues require the glue applicator to be heated above room-temperature and maintained - within a fairly narrow limit - at the correct temperature for the materials being used. For hot-melts it is also important that the adhesive should be at the optimum temperature when applied to the wood. For this reason, it is important that the temperature of the application rolls, as well as the glue reservoir, is accurately controlled. The reservoir should also be capable of raising the temperature of a large mass of adhesive quickly to reduce starting-up time.

37. For large areas, and for edging processes, roller application is the most widely used technique. Rapid and positive adjustment of coating weight is important and the machine should be examined to see how readily this may be achieved. In the tropics, it may also be an advantage to cool the glue rollers and glue reservoir to prolong the pot-life of the adhesive.

38. Application to profiled surfaces, e.g. with grooves or dovetails, can be difficult and spraying is an obvious solution to the problem. To-day, however, the difficulties of spraying high viscosity glues, often containing particulate fillers, have proved difficult to overcome and joining machines with spray applicators are still in the early stages of development; the use of glues with limited pot-life is also a problem when spraying, as all pipe-work and nozzles will require frequent cleaning.

39. Application of glues to profiled edges, mortices, dowel holes and other difficult areas can often be carried out with a specially shaped nozzle fed from a pressure pot.

40. Since the gun, nozzle and pipes remain full of adhesive, glues with limited pot-life are unsuitable. PVAc is the usual material for use with such equipment, but UF resin, without hardener, can also be used. The hardener can be pre-applied to the opposite face of the joint, and curing commences when the two are brought together. Hardeners are available which may be allowed to dry completely on the wood before use.

41. Special application techniques are further described under the individual machine sections.

(v) Location of Parts and Applying Pressure

42. Maintaining adequate bonding pressure during the setting of the adhesive is probably the most important function of any joining machine. The pressure required is largely determined by the nature of the components, thick uneven materials requiring higher pressures than thin accurately surfaced ones. For veneering and applying thin edging strips, 3-5 kg/sq. cm. is sufficient, whilst thick boards, being joined or laminated, may require up to 14 kg/sq. cm. to bring them into contact. These pressures are specific and when selecting a piece of equipment it is important to confirm that the total force which it can exert is adequate for the largest bond area required.

43. Bonding pressure should be maintained consistently whilst the adhesive sets, which in some cases can take several hours. Screw clamps do not automatically follow-up the consolidation of the joints, which takes place whilst the adhesive flows, and pressure consequently diminishes. This may be partly overcome by the insertion of a resilient material such as thick sheet rubber between the press plates and the work pieces. Alternatively springs may be inserted to act in the same way. Pneumatic and hydraulic systems automatically compensate for small movements in the joint and are thus to be preferred.

44. Whatever the means of applying pressure, it should be distributed evenly over the entire joint area. In addition to sufficient total force, therefore, machines should be examined to ensure that platens, pressure bars and so on, are sufficiently stiff to achieve this. Hydraulic systems usually act through rams, but for some uses it is possible to apply pneumatic pressure direct, via inflatable bags or hoses. For curved work too, it is possible to apply pressures up to 1 atmosphere by covering the work with a flexible rubber sheet and exhausting the air from beneath it with a vacuum pump.

(vi) Adhesive Setting

45. Rapid gluing usually requires some form of heat, where components are thin this may be applied directly via a heated body, for example in veneering and lipping.

46. From a design point of view, it is important that any heating device should maintain its operating temperature, when being constantly re-loaded with cold components, therefore heavy platens and heater bars are needed to provide the appropriate heat capacity.

47. When components are narrow, a convenient technique is to heat the joint via a thin flexible steel strip which carries a high electric current at low voltage. Such equipment can be rapidly made to suit a variety of components and capital cost for suitable transformers is low, often less than £100 sterling. The same transformer can be used with different jigs as sizes and shapes of work are changed.

48. Heat may also be generated directly in the glue and/or wood by the use of radio-frequency (di-electric) methods. Capital cost is high but individual joints can be cured very quickly, sometimes in less than 10 seconds. Applying the energy to glued joints requires complex jigs and fixtures. Whilst these are normally made by personnel in woodworking firms, specialist training is required.

II <u>PROCESSES</u>

(i) <u>Edge Bonding</u>

(i)a <u>Veneer Splicing (31.1</u>)

Introduction:

49. In the manufacture of plywood, laminboard, blockboard and veneered chipboard the outer veneers and, in the case of exterior plywood, also the core veneers, are invariably formed by fixing together several narrow widths of rotary-peeled or sliced veneers. This joining process demands veneers that are cut in absolute alignment and true to angle at the edges. For rapid and durable gluing the edge qualities necessary are evenness and smoothness in order to ensure a tight joint over the entire length of the veneer. This preparatory work - the so-called veneer jointing - requires special equipment and can be achieved in different ways i.e. by saw, knife, cylinder head cutting or planing. The two latter methods fulfil maximum requirements as regards quality and they predominate in high capacity production. Some manufacturers of jointing equipment use two cuts per edge, i.e. after the first rough cut an adjustable additional cutting device comes into operation which performs a paring cut that can be adjusted to remove between 0.5 and 2.0 mm. ensuring that the jointed edges are both at right angles and straight. Notching of the edges is thereby eliminated. (Fig. 1).

50. The principal operations of veneer jointers or trimmers can be summarised as:

1. Veneers in piles - any other method would be uneconomical - must first be aligned to obtain the smallest possible cutting waste.
2. Manual or automatic charging of the jointer.
3. Consolidating the veneers until the edge of the mass exposed to the cutters has all the appearance of a solid block of wood. (The pressure applied is normally equivalent to that used during composition or subsequent gluing processes.)

4. Cutting, milling or planing the veneer edges.
5. Removing splinters and cutting waste.
6. Automatic glue application, which on most machines is an optional extra.

51. The simplest manual glue applicator consists of a trough in which there is a dosing plate. Glue is applied on the edges of the veneer stack by means of a lambswool type roller. With a cut edge length of 2700 mm, this operation requires approximately 10 seconds irrespective of the veneer pile height in the jointer. A more advanced glue applicator travels automatically, after the last cut, over the prepared edges of the pile of veneers and by means of a built-in doctor roller a thin and uniformly distributed film of glue is spread on the surface. Recently, a glue applicator was introduced which is designed to apply glue to both edges of single sheets of veneer in a continuous process requiring only one operator. A compressed air control system presents a quick thickness regulation and adjustment to different veneer species. Roller conveyors transport the veneers from the first to the second gluing unit at high feed speeds. This method is said to give a cleaner glue-line than the conventional method of edge gluing veneers in packs. To facilitate visual assessment of glue spread it is advantageous to add a suitable dyestuff to the glue mix.

52. Once the veneer edges have been prepared in the jointer it is advisable to proceed with the next operation as quickly as possible to reduce the risk of any change in moisture content, this is particularly important when working on veneer with interlocked grain.

Veneer Splicing Machines (31.11)
Paper Taping Machines (31.111)

53. Prior to the invention of edge-joining machines, wood veneers were joined by manually sticking adhesive coated paper over the joint; adhesives generally used were animal glue or dextrine based. Veneer taping by hand is still used on a limited scale, particularly in joining fragile veneers.

54. The introduction of power driven taping machines some 40 years ago created a greater interest in this taping method. The advantages of using a machine are:

1. Labour saving, the machines requires only one operator (usually female).
2. Improved quality due to the precision joints obtained.
3. Simple operation due to the easily accessible arrangement of all the operating equipment.

55. Taping machines use a paper tape that is coated with a water activated adhesive and the tape is fed from a reel. It touches a wetted roller and then travels onto a pressure wheel with the adhesive coated side outermost. The two leaves of veneer to be joined are fed to leading rollers and the tape is then automatically pressed over the joint. The tape itself is generally made from kraft paper in various widths (5-25 mm) and various thicknesses and is obtainable as solid or perforated. The perforation may be round or oblong in single or double rows. The most important quality criterion for the paper is its tensile strength both in the dry and wet state. The ideal tape is one which can be easily removed after it has served its useful function. An advantage of the taped joint is that it forms a hinge and so thin veneer can be folded and stacked. It has however also the following drawbacks:

1. Cost of the tape.
2. The need to sand off the tape i.e. an additional finishing operation.
3. Limited usage.
4. Faulty interior gluing due to the tape, particularly in phenolic bonded plywood.
5. Risks of an 'open joint'.
6. Difficulty in obtaining a good joint with veneers of differing thickness.

56. Taping machines are designed not to rely on particular skill on the part of the operator. It is claimed that even delicate and buckled veneers of any thickness can be joined without showing machine marks.

57. In one type of machine the power driven top pressure roller feeds the veneer through and, working in conjunction with the horizontally rotating inset table-disc, ensures that the joints are always tightly pressed together. The converging pressure at the joints can be adjusted by hand according to the type and thickness of the veneer used. The guides for the gummed paper tape are accurately placed so that the tape is always applied over the centre of the joint. Tape consumption is economical since a photo-electric cell stops the veneer immediately behind the pressure roller and the feed is only resumed when the next veneer is inserted. The tape is severed by means of a patented automatic parting-off arrangement combined with the outfeed roller. The temperature of the heated pressure roller is infinitely variable. Feed speeds may vary between 8 and 21 m/min. Veneers of between 0.3 and 5.0 mm can be taped.

58. In another type of machine the joined veneer is withdrawn by pushing it between a driven outfeed roller and a wheel, which accelerate when the next veneer enters the machine breaking the adhesive tape.

59. In the manufacture of sliced oak veneer, for example, many joints will be needed before a sheet of the required width is obtained. In this case the off-bearer returns the taped veneers to the feed end of the machine where additional leaves are added. Where wide sheets are being manufactured it is advisable to extend the table of the taping machine with a sheet of plywood to form an area sufficient to support the entire sheet. In this way it is possible to slide the veneers to and fro without risk of damage.

60. Taping machines are fast and practical, requiring very little attention as far as repairs and maintenance are concerned. As only women workers are usually employed, a special mechanic is in charge of all running repairs.

61. A machine recently developed can make use of either gummed tape or hot-melt impregnated fibre glass thread. This machine fills a gap in the requirements of the woodworking plants that have not installed additional, specialised machines for reasons of cost or space. Changing over from tape to fibreglass is achieved in a few minutes.

Tapeless Jointers for Veneer

62. The principle of the tapeless jointer or so-called veneer splicer is that glue is applied to the prepared edges of the veneers which are then butt jointed. The most commonly used glues are urea formaldehyde and PVAc.

63. There are two types of machine, one in which the joint is formed transversely and the other longitudinally. (Figure II)

Longitudinal Veneer Splicers

64. These machines can be supplied with built-in glue applicators. Here the veneer edges are automatically coated with glue by contact with the side faces of a rotating gluing wheel placed vertically. (Figure III.) The glued edges are then brought together. Alternatively, the glue may be applied in the edge trimmer after preparation of the edges. (Figure IV.) There is also a method in which a hot-melt impregnated fibre is used instead of coating the edges of the veneer with glue.
Operating details: Two strips of veneer, the edges of which have been previously jointed and glued are laid flat on the work table at the infeed of the machine. Two pairs of converging top and lower track feeding chains apply the required pressure on the veneer edges over the full length of the veneer strip while it moves through the machine. Heat to cure the glue is applied from above and below between the chains directly on to the joint. The drive is transmitted to the upper and lower chains through an infinitely variable gear box over powerful drive shafts. The speed can be regulated between 10 and 30 m/min. depending on veneer thickness, wood species, heater bar temperature, veneer moisture content, type and reactivity of glue. A speedometer is usually provided. Two solid heater bars, tapered, hard-chrome plated, and polished are used in contact with the glue-line. The temperature (electrical resistance heating) can be varied between 130-250°C. It is advisable to set the upper heating zone about 40°C. higher than the lower one due to its greater heat losses. With delicate, decorative veneers the temperature of the heater should not exceed 230°C. as there is a danger of discolouring the veneer surfaces. Veneer thickness

of 0.4 to 5 mm. may be glued but in general thinner veneers are preferred. Curled or wavy veneers are flattened between the chains preventing warping or rolling up. For joining decorative and constructional veneers in thickness of 0.3 to 3 mm. a glass thread impregnated with hot-melt adhesive may also be used as joining medium. This thread is applied in zig zag or wavy line fashion across the joints via a heated thread-guide, and rolled into place. The operation is simple and high efficiency may be achieved. Normally the spliced face of the veneers is placed in contact with the glue-line during panel make-up thus sanding complications are eliminated. Such machines are obtained in various sizes down to hand applicators. This type of jointing requires only one operator (usually female), eliminates the cost of tape, and sharply reduces sanding costs. A well produced joint shows no visible glue. The machines are ruggedly constructed assuring dependable performance and long life. Maintenance is comparatively easy.

65. The passage of the joint lengthwise through the machine must inevitably be slower than a method wherein the joint is passed transversely. A transverse or cross-feed joining machine therefore has the advantage of higher output but normally requires the edges of the veneer to be glued as a separate process.

<u>Transverse or Cross-Feed Splicers</u>

66. There are two types of cross-feed splicer:

(a) discontinuous
(b) continuous

(a) In this method, the splicing or curing cycle takes place when both veneers are stationary. (Figure V.) In other words each joint is glued individually. The quality of the joint is assured by pressing the longitudinal edges of the veneer together. The veneers already joined are statio and the leading edge of the next piece is advanced until it meets the fixed veneer. A glue-line pressure of up to 75 kg per cm. joint length can be exerted depending on wood species and veneer thickness. Gluing in cycles has the advantage that only the actual joint - and not the complete veneer sheet - is heated by an upper and lower heater beam of 100 mm. width. The operator places the previously glued veneer edges against stops located in the middle of the heater beam. These stops then retract automatically. The heat sources are 10 kw and the temperature can be regulated between 100 and 300°C. Veneer transport speeds are eight times faster than in continuous operating machines, so that wide veneer pieces pass quickly to the curing position. Veneer of between 0.3 and 5 mm. thickness can be glued. The claimed outputs are as follows:

Thickness	Joints/minute
0.5 to 1.5 mm.	19 - 22
1.5 to 2.7 mm.	15 - 18
Greater than 2.7 mm.	9 - 15

67. A high speed veneer guillotine on the take-off side of the machine cuts the continuous strip to any desired length; following the guillotine there is a 'rise and fall' table. In order not to damage the freshly glued and cut veneers the platform height continuously adjusts allowing them to drop only 10 cm. After each cycle the platform drops a distance equivalent to the thickness of one veneer thereby maintaining the 10 cm. drop.

68. The advantages of this machine are: ease of removal of cured glue adhering to the heater bars; elimination of the need to cool the sheets, as only the joint areas are heated, thus reducing the possibility of shrinkage of the veneer due to loss of moisture. The disadvantage is that relatively wide veneer pieces have to be used to obtain high outputs, particularly with veneer thicker than 1.5 mm.

(b) Continuously operating cross-feed splicers.

69. In one type of machine, use is made of top and bottom feed chains ensuring positive and accurate feeds through the machine but leaving no marks on the veneers. The electric heater bars are chromium plated. Height adjustment of the upper machine bed for a given veneer thickness is accomplished by a gauge which regulates the gap to the nearest 1 mm., fine adjustment is made by hand. To eliminate the running-away of a glued up sheet, the movement of the transport chains is stopped automatically by a photo-electric cell when the feed is interrupted. The trailing edge of

each veneer sheet remains at a specific point inside the 'waiting zone' until the leading edge of the next veneer is properly bedded and the gap between the two pieces fully closed. Wedge shaped veneers are aligned automatically. Veneers down to 1.2 mm. thickness can be used. Feed speeds can vary between 3 and 12 m/min. depending on veneer thickness, moisture content and machine temperature.

70. In another machine the top and bottom cam operated heater bars reciprocate on rollers. Adjacent bars move alternately, gripping the veneer strips and feeding them through the machine under a pre-set pressure. The large area in contact with the water-heated bars ensures overall, even heating to cure the glue and flatten the veneer. The machine can be equipped with a pre-feeder which prevents veneer strips remaining stationary within the heated zone. Thus, even with the thinnest veneers no marks, scorching or localised dry spots can occur. A cooling system can also be attached to the out-feed end.

71. Both types of machine can be used in double operations using narrow veneers.

72. The advantages of these machines are:

1) Normally joints of the highest quality are obtained.
2) Greatest utilisation of timber - very narrow strips can be used.
3) Low waste.
4) High output.
5) One man operation.
6) Combines three operations: gluing, cutting and stacking.

73. The drawbacks may be summarised as follows:

1) High capital outlay.
2) Accurate installation essential.
3) Veneer thinner than 1.0 mm. cannot normally be used.
4) Heater bars are difficult to clean.
5) Adjustments are more difficult.
6) Maintenance relatively more difficult.

(continued..)

7) Without cooling system veneers leave the splicer at a temperature of over 100°C.

8) Separate heat source.

74. Cross-feed splicers(composers) utilising hot-melt impregnated glass fibre as gluing medium are of fairly recent origin.

75. One type of machine applies pairs of hot-melt impregnated thread that are interwoven between the veneers, as shown in Figure VI. Veneers of up to a length of 2800 mm. in the grain direction and thickness between 1.5 and 6 mm. can be accommodated. The output depends on the width of the individual pieces as well as the nature of the veneer.

76. In another type of composer for cores, a hot-melt impregnated fibre glass thread is pressed into the veneer using an adjustable spring pressure system. The resultant flat strands hold the veneer pieces together. 2.5 to 6 mm. thick veneer may be joined by this method at a rate of up to 34 metres/min. The basic unit may be augmented by a veneer 'tenderiser', which relieves veneer surface stresses, trims the edges, and brushes the surface clean; a hot-melt coating plant to impregnate the fibre glass threads; a wedge detector system to monitor veneer skew, and a vacuum veneer stacker.

77. This method of veneer composing offers high output rates without heating the veneer at all. Therefore, there is no waiting time for the veneers to cool. So far it would appear that certain softwood species lend themselves better to this jointing with fibre glass than hardwood species. During subsequent processing blisters may occur in the vicinity of the fibreglass due to an excess of hot-melt or insufficient flattening of the thread which gives rise to local variations in veneer thickness. It is an ideal method where high output rates are essential, particularly in the manufacture of sheathing panels.

Other Methods of Veneer Jointing

End Gluing of Veneer

78. Justification for end gluing of veneer lies primarily in the potential benefits of using very short peeler logs, salvaging short lengths of high grade veneer and in the fabrication of long lengths of plywood.

79. Scarf jointing, in other words the gluing together of bevelled ends of veneer is successfully being used on an industrial scale. A well made scarf joint is almost as strong as the veneer itself. The working qualities of scarf jointed veneers are equivalent to those of unjointed sheets and strength properties are only slightly effected. After sanding a scarf joint is hardly visible.

80. The veneers are fed on supports to saw blades, the angle of whioh can be adjusted according to the thickness of the veneer. Press plates close to the saw blades flatten the veneer ends. The saws bevel each end of the veneer with the reverse angle and glue is then automatically applied to one end. The feed speed is variable from 11 to 35 m/min. A heated scarfing press joins the bevelled and glued ends of the veneers in the direction of the grain and then cuts the resultant sheets to the required dimensions. The temperature of the platens in the press can be varied up to 230°C and a gluing pressure of up to 12 kg/cm^2 can be exerted.

81. Recently a concept has been put forward for finger jointing sheets of veneer into long lengths based on 'impression' finger jointing.

82. Unlimited lengths of veneer make possible the fabrication of long length plywood either continuously or in long flat platen presses. Long length plywood offers important design and fabrication advantages in boat building and other structures.

(i)b Solid Wood Edge Joining (31.12)

83. Where wide panels (say, greater than 300 mm.) are required, it is usually necessary to joint boards edge to edge. In the furniture industry wide panels are normally made from sheet materials such as plywood, blockboard or particleboard. In very high quality furniture, however, where solid timber is still used wide panels are needed, e.g. for table tops and chair seats. Additional uses are in the manufacture of simple concrete shuttering boards, coffin boards and freight container or vehicle floor boards. Assuming the boards have been square-edged by a suitable process and glue applied, they must be assembled and pressure applied whilst the glue sets.

84. Applying edge pressure to a series of boards can cause them to lift in the centre, giving rise to bowed components and partially open joints. For this reason presses and clamps used in the edge joining of timber must incorporate a device to apply a vertical pressure to counteract this tendency and ensure that the finished boards are completely flat. Seen purely from the point of view of making a well glued joint, the edges of boards need merely to be cut at right angles. Location of the boards to prevent the bowing tendency described above may often be achieved by machining their edges with a tongue and groove, or some more complex profile. Whilst this may obviate the need to apply downward pressure to the panel during clamping, it does not enhance the strength of the glued joint itself.

85. Before the development of fast setting glues, a technique of edge-joining boards was developed in which they were tightly located without the need for clamps. In this process, one or more dovetails and corresponding grooves were machined in opposing edges of the boards. The male and female parts were fed into the machine from opposite ends and after forming the dovetails glue was applied. The boards were then slid together from opposite directions so that the dovetails mated and this movement was continued until the ends of the boards were in line. To produce wide panels, single boards had to be added to the first pair until the desired dimension was achieved. The realisation that strong glued joints could be produced without any special profile being applied to the edge, and the

development of machinery to clamp wide panels have contributed to the declining use of this process. Machining plain edges also wastes less wood.

Hand Cramps

86. The simplest method of applying pressure to a number of boards is by long hand cramps (Sash cramps). These will not control the tendency to bowing and some examples therefore incorporate a long arm with a pressure pad mounted at the centre, which is sprung into place after the side pressure is applied, restraining the tendency to bowing. (Figure VII)

87. For higher volume production, groups of two or more clamps, depending on the length of boards to be joined, are mounted on chains or clamp carriers. Such multiple assemblies are referred to as 'windmill' clamps.

88. In practice a set of clamps is loaded with pre-glued boards and then tightened. The operator then raises the set towards the vertical position, bringing a further set into the loading position. This process is repeated until the clamp carrier is full and the first assembly has returned to the operator for unloading. By appropriate selection of an adhesive with a quick setting time and a suitable length of track, such a unit can produce an almost continuous series of glued assemblies during the working day.

Mechanical Clamps for Accelerated Curing

89. Where even higher outputs are desired the glue-lines must be heated. Hydraulic presses providing both side and top pressure to packs of boards can be modified to include heating elements. Such presses are often used for the manufacture of container floors and in one type, heat is provided by a steam or hot water heated platen, which is bought to bear on the surface of the assembly. Where the assembly is thick (15 mm. or over), however, complete cure of the glue-line cannot be achieved in an economic time and initial strength of the assembly must rely on curing the glue-lines to a depth of only a few millimetres from each face. A fully cold-curing glue must therefore be used so that the inner (unheated) portions of the glue-line will cure subsequent to removal from the press.

90. In such equipment 30 mm. thick laminated floor boards can be tacked adequately in 1 to $1\frac{1}{2}$ minutes with a platen temperature of 130°C.

91. An alternative to steam heated platens is the use of radio-frequency systems, the mechanism and advantages of which are discussed elsewhere in this paper. The edge jointing of boards in RF-heated presses often involves materials of random widths. It is therefore not possible to locate a pair of electrodes directly over each glue-line and a solid bottom electrode with a mesh top electrode are often employed. The random distribution of glue-lines between such electrodes ensures that each glue-line is covered intermittently and between $^1/3$ and $^1/2$ of the total glue-line area can be cured in this way. This also ensures that the total radio frequency input to the press is kept to an economic level. Again, however, it is necessary to use an adhesive which will finally harden at room-temperature in the areas not subjected to the RF field.

92. The two preceeding types of machine are designed to deal with the problem of curing the glue in deep glue-lines where heat penetration is slow. A further method of overcoming this problem is to pre-heat the strips before application of the adhesive. A suitable type of glue for such a process is a urea formaldehyde resin with separately applied hardener. With such a system curing does not begin until the hardener coated half of the joint makes contact with the resin coated half.

93. One example of a machine using this process assembles random widths of board into a continuous strip on the lines of a cross-feed veneer splicer. Outputs of up to 2 linear metres a minute are claimed, the resultant strip being cross cut to the required length at the end of the machine.

(i)c Solid Wood End-Joining (31,122)

94. End-joining of timber has three main advantages:

1. Short lengths of timber, normally discarded, can be converted into useful material.
2. The quality of low grade material can be improved when defects such as large knots are cut out and the pieces rejoined.
3. It removes the limitations otherwise imposed by the available lengths of sawn timber.

95. Basically, an end joint is made by machining the ends of the lumber and gluing them together to form (in theory) unlimited lengths.

96. The main requirements of any end joint should be:

1. Simple to produce.
2. Capable of resisting the forces to which it is subjected.
3. Minimum timber wastage in production.

97. There are three types of end joint:

1. Butt joints
2. Scarf joints
3. Finger joints. (See also ID/WG.151/5)

98. The first two have been widely accepted for many years but finger jointing has only recently come into use on a large industrial scale.

Butt Joints

99. The butt joint is the simplest type of joint. The ends need only to be squared by saw and hence the loss of material is negligible. However, as the joint is formed between end-grain surfaces it is the least efficient of all joints and thus the practical applications are rather limited.

Scarf Joints (31.122.2)

100. A scarf joint is formed by cutting a sloping plane on the ends of the timber to be joined; the slope usually being visible in the thickness of the timber. The plain scarf joint is undoubtedly the most frequently used by reason of its simplicity and high strength. The strength of a scarf joint depends mainly upon the slope of the surfaces; the flatter the slope and hence the nearer to the side grain condition, the stronger the joint. Experience has shown that joints with a slope of 1 in 12 or more can have as much as 90% of the strength of unjointed timber. The joint surfaces of the scarfs must be true in plane, free from tearing and chattering marks since for maximum strength a close contact joint is required even when a gap-filling adhesive is used. Although it is possible to make high strength scarf joints with sawn surfaces, in practice more consistent strength is obtained by planing the surfaces parallel to the grain. Hand cut scarfs tend to be weak as there is a tendency to hollow out the surfaces slightly in order to admit a close fit at the edges of the joint.

101. Glue spread on scarf joints should be at least twice that normally used for side grain gluing because of the great absorption on the open grain of the scarfed surfaces. The speed at which the end joints have to be mated and cured depends on individual requirements. If few joints are required they can be put together and cramped up in a batch using ordinary cramping equipment and left to cure with or without heating. (Figure VIII.) A batch of scarf joints made in this manner may have to be left for 24 hours or so under pressure to ensure they are strong enough to handle. When gluing up a plain scarf it is advantageous to allow the tips to overlap very slightly. With an overlapped joint the clamping force will tend to press the faces together while sliding the two halves into line but an incompletely overlapped joint will be forced apart by the clamping pressure.

102. Scarf jointing is a slow process, if the scarf has to be held in clamps throughout the room-temperature curing time of the adhesive. For quantity production special equipment which applies pressure and heat is needed.

A hydraulic or pneumatic system is used as standard pressure equipment, and heat curing of the glue is usually done by radio frequency heating or high-temperature elements. One major problem with plain scarf joints is that they are difficult to align, locate and hold accurately for gluing up. In order to overcome this a number of modifications to the plain scarf have been developed. Common modifications for this purpose are end-steps, hooked scarfs, hooked and stepped scarfs, wooden dowel or aluminium nail indexing. Although the plain scarf can produce an entirely satisfactory joint it suffers from the following disadvantages:

a) It is difficult to locate.

b) It involves wasting a piece of timber equal to twice the length of the joint. A 1 in 12 scarf in 38 mm. thick wood 3.7 m. in length wastes 12½% of the wood.

Finger Joints (31.122.1)

103. A conventional finger joint is produced by cutting tapered projections i.e. 'fingers' on the ends of the wood to be joined after it has been trimmed square and then gluing and assembling them. In structural work the joints are usually horizontally cut i.e. have the finger profile visible on the face of the board. This has been shown to give joints stronger than vertical cutting i.e. with the fingers cut in the edge of the board. Horizontal cutting also has production advantages in reducing cutter wear, enabling a uniform finger pitch to be used whatever the board width and also giving minimum path for dielectric heat curing of the glue.

104. The joints take various forms depending on the length and pitch of the fingers and on the width of their tips. The strength of finger joints depends largely on the geometry of their profile. The recent introduction of a mini-finger joint provides a smaller joint of potential use in both structural and joinery application thus further saving timber.

Glue Application

105. After preparation of the fingers, joints should be assembled as soon as possible to avoid warping due to moisture content changes. The glue may be applied by means of a brush, a glue template, by profiled glue wheels or by an airless spray system. In most cases glue is only applied to half the joint. It is, however, necessary to apply sufficient glue to ensure that the entire profile has been properly coated. Technically, it is not easy to apply a minimum and sufficient quantity of glue into the comparatively long and narrow profile without any losses. This means that in practice, in the majority of cases, glue losses do take place causing fouling of the machine parts. In general it can be safely stated that the problem of glue application has in many cases not been solved satisfactorily. It would be advantageous to apply the glue to both parts of the finger joint.

106. After the ends have been suitably prepared the pieces are ready to be pushed together to give the long section. An important factor in joint strength is pressure during gluing. There are two basic methods of pushing the fingers together. In the first, one piece of timber is clamped with the fingers just beyond the clamping pad and the second piece is brought up to it and this is also clamped. Then the two clamps are brought together under pressure. This forces the pieces together and is known as static pushing since during the operation one piece does not move. In the second method the movement of the first piece is restricted by a brake, whilst the second piece is advanced by means of wide top and bottom tracks forcing it onto the first. The tracks move the second piece along until it is under the braking section when the track starts pushing a third piece onto the fingers at the end of the second and the process is repeated. This is known as the continuous method as the timber is moving all the time.

107. The optimum gluing end pressure depends on the geometry of the fingers as well as on the density of the timber. The minimum short term

end thrust pressure for softwood is given in DIN 68140 as:

- about 120 kg/cm^2 for 7.5 mm. long fingers
- about 20 kg/cm^2 for 60 mm. long fingers.

For hard woods pressures should be at least 30% higher. This pressure has to be maintained until all the excess glue has been squeezed out of the joint. Furthermore, vertical pressure is of assistance in keeping the joint halves in line.

108. The effect of end-pressure is to spread the outer fingers of the joint, and, in the extreme, to burst the timber. Side pressure is thus required to maintain a smooth exterior and resist splitting. DIN 68140 recommends

20 kg/cm^2 for softwood,
and 30 kg/cm^2 for hardwoods.

Side pressure must be maintained until the tips of the outermost fingers are bonded and the specification further requires that this pressure should not fall below 10 or 20 kg/cm^2 respectively, during the bonding period. The rapid bonding of these outer finger tips may conveniently be accomplished with RF heating or small heated blocks which form part of the side clamp. Only a few millimeters of glue-line need be tacked to ensure bonding at this stage; the remaining glue-line curing at room-temperature later.

109. Recently, a new type of finger called the die formed finger joint has been developed. Here instead of timber being removed by cutters a die is forced into the ends of the timber to mould a finger joint pattern. The main advantage of die formed finger jointing is that the fingers are short i.e. 5 mm. or so. Indeed, with this type of joint the length of the fingers must be controlled to avoid splitting the timber. This results in a very small waste of timber and is particularly important if off-cuts and short lengths are to be reclaimed. Although the joint produced by this technique is not sufficiently strong to be used for structural purposes it

has great potential in joinery and other non-structural applications. This factor together with the claimed machine performance of a jointing cycle of 6 seconds ensures a considerable future interest for the die formed end-jointing machine.

110. The range of machinery for clamping all these types of joints is very limited. We have therefore considered the requirements of the process in detail. Finger jointing clamps usually form part of a complete system which includes cutting, gluing, curing and cross-cutting the jointed material.

(i)d Panel Joining (31.13)

111. The technique of increasing panel areas has become quite important due to the potential benefits in salvaging off-cuts of, for example, high grade particleboard and plywood; also owing to the rapidly growing demand for large sheet material such as is required for boat hulls, glider wing skins, packing cases, sub-floors in caravans, plywood-web, 'I' and box beams. A wood joint is designed to transmit longitudinal stress in the product and save material otherwise too short for use. An adhesive bonded joint, which spreads the load over the full area of the joint, is usually stronger than mechanical fastening which concentrates the load in a small area. Assuming therefore that adhesives are to be used for joining, the ideal joint should have the following characteristics:

1. It should waste little material.
2. Its strength should approach or preferably equal the strength of the material from which it is made.
3. It should be prepared easily, with a high degree of accuracy and uniformity.
4. It should preferably be self aligning.

Machinery and tools should not require special and costly maintenance.

112. Panel joining may be accomplished in a variety of ways. The commonest, simplest and most satisfactory method is to make a plain butt joint, well glued with a gap-filling adhesive. Provided that the standard of machining is good, i.e. cut in absolute alignment and true to angle, the boards may be glued together with the edges straight from the saw without the necessity for planing. Preferably both edges should be well coated with glue because these are frequently open-grained, particularly in particleboard. The joint should then be kept under pressure until the adhesive has cured. The cure may take place under room-temperature conditions and the pressure may be applied by sash cramps, 'windmill' cramps or by some other method. Accelerated setting may be achieved by the application of heat and this may conveniently be done by high frequency glue-line heating (c.f. - iv Edge Banding below).

113. In the case of particleboard no matter what curing method is used the resultant joint approaches the strength of unjointed areas. The porosity of the edges of particleboard permits an excellent anchorage for the adhesive, i.e. the formation of good mechanical adhesion. Tests on the bending strength of butt jointed particleboard showed that on average 70% of the strength of unjointed boards was obtained.

114. Scarf jointing, as has been practised by carpenters for generations, is another very common technique of obtaining large surfaces. Fundamentally, this is a tapered joint that does not increase the thickness of the original sheet material and retains a high proportion of its strength. The panels to be joined are chamfered to the correct angle which varies from 1:12 for boards under 12 mm. thick to 1:8 for 12 mm. thick or over giving angles of $4\frac{3}{4}$ and 7 degrees respectively. To ensure good adhesion over the entire joint, the machined scarfs must be brought into close contact. This demands very accurate workmanship as nothing short of perfect surfaces will suffice. In jointing plywood panels experience has shown that the best results are obtained if a bobbin sander is used for boards of 5 mm. or less and a saw or cutter head for thicker boards. During cutting of the scarf the boards must be firmly supported to obviate chattering. The usual practice is to apply either a cold or hot curing, gap-filling adhesive onto one scarf only and to bring the surfaces in close and

complete contact. The two pieces should be so positioned that the thickness over the length of the scarf is a fraction greater than the thickness of the original panel. This will ensure even pressure over the joint area and also allow for compression losses. During the pressing cycle there is a tendency for the two pieces to move apart which has to be counteracted by some restraining force. This can be done by applying pressure to the panel outside the scarf, by means of additional air or hydraulic cylinders before pressure is applied to the joint. This restraining force is very important as otherwise the glue will not be under pressure and thus produce a poor joint. (Figure IX.)

115. Pressure can be applied by an inflated hose backing the flexible steel plates. By this means uniform pressure can be obtained at modest cost. Alternatively, a conventional hot or cold press with several daylights may be used. The hot press may be heated by water, steam or electricity. A fast method of curing the glue is to use RF transverse or through heating.

116. Scarf jointing of panels is a slow, difficult and expensive process particularly if high strength is required. It is also wasteful of the product. The strength of scarf joints can be greatly influenced by the quality of the manufacturing processes involved, and joints that are not properly machined, mated and glued will not have a high strength.

117. Lastly, in this connection, some plywood is finger jointed to make longer panels. Tongues and dowels are also used to a limited extent in joining chipboard but they are only used for location and they do not add appreciably to the strength of the joint. Again, such joints require very accurate setting of the machine.

(ii) Squaring-up Processes (31.2)

118. Repetitive manufacture of joinery components, such as windows, and furniture items such as carcasses, requires specialised clamping arrangements which will locate the components and apply sufficient pressure to ensure that all joints are fully consolidated in their final positions, maintaining pressure whilst the glue cures.

119. In most cases location of components in the final article involves establishing true right angle joints. For both furniture and joinery, it is not only necessary to locate the main components but intermediate ones as well, for example, glazing bars or mullions in window frames and internal divisions in cabinet carcasses.

120. Clamping devices must therefore be selected in relation to the range of articles which they are to produce.

121. Frame and carcass clamps employ the following basic features. A robust, rigid framework on which pneumatic or hydraulic pressure devices can be quickly mounted in positions which suit the work in hand. Additional cylinders are required for applying pressure to intermediate rails or partitions. Pressure can be applied by pneumatic piston operated cylinders terminating in suitable blocks or bars to transfer pressure to the components being clamped. Alternatively, hose-operated thrust members may be used.

122. If the joints to be assembled are wide, as in the corners of furniture cabinets, the cylinders may need to operate via pressure bars distributing the applied force evenly over the whole joint area. In such cases an alternative arrangement is to use short lengths of hose which when inflated bear on suitably shaped blocks which apply pressure to the components in the clamp. More advanced designs may also locate electrodes for radio frequency curing processes. RF is particularly valuable in assembling cabinet furniture.

123. The total thrust required to assemble large components is considerable and may result in distortion of the main clamping frame. It is preferable, therefore, to select units which have large diameter rods or heavy channel section frameworks, so that the final components can be reproduced with the maximum accuracy.

124. The corners and intermediate rails of joinery items normally include comb or tenon and mortice joints. Where large cross-section timbers are used the linear displacement of components before the joints are fully closed is considerable. For such items, clamps should be selected in which the pressure members can travel over an adequate distance. In this respect hydraulic or pneumatic rams are preferable to air hoses.

125. Pneumatic rams normally move rapidly from the closed to the open position, an advantage where high production rates are required. All pneumatic equipment, however, relies upon a main source of compressed air within the factory. Where this is not available, hand pumped or electro-hydraulic systems may be preferable, requiring no additional services or, in the latter case, only a suitable electrical supply.

126. Comb or tenon joints or their derivatives, although they do not automatically ensure the squareness of the finished component, do limit its overall dimensions. In the production of furniture, from for example, particleboard, mitred joints are often used at the corners of the main assembly. These do not automatically locate in the right position and may ride over one another giving rise to varying dimensions of the finished cabinet and unsightly exposure of the core material at the corners.

Where such joints are to be made in quantity a press should be selected which applies the corner pressure via a v-block which locates the joint components accurately, as well as maintaining the squareness of the finished article. (Figure X.)

127. When assembling cabinets which include a large number of individual components it may be advantageous to present different parts of the assembly to the operator during the manufacturing process. For this purpose carcass clamps are available which are pivoted and may be rotated about a horizontal axis whilst full clamping and locating pressures are applied. With such machines it is essential that the framework is sufficiently robust to resist the additional loads without distortion.

(iii) Surface Joining - Veneering Presses (31,33)

Definition of Veneering

128. The veneering operation consists of gluing sliced or rotary-peeled veneers to flat or contoured cores such as solid wood, plywood, particleboard and hardboard. The bonding of the veneers may be achieved in one of several ways.

a) Cold pressing for flat surfaces.
b) Hot pressing in multi-daylight presses for flat surfaces.
c) Hot pressing in flow-feed single daylight presses for flat surfaces.
d) Ratchet or hydraulic presses using specially shaped, rigid, male and female moulds.
e) Vacuum and dome presses in which there is only one mould and a rubber bag or sheet to apply pressure.

a) Cold Pressing Process and Equipment

129. The core material that has previously been coated with a suitable cold setting or curing glue-mix is assembled with veneers in the desired

manner, and a large number of such assemblies is built up on a heavy woo.en caul, or retaining board. Once the load has been completed a second caul board is added and pressure is then applied.

1. Retaining Clamps

130. The simplest and cheapest way of applying and retaining pressure is to use retaining clamps and 'I' beams. (Figure XI) Retaining clamps consist of upper and lower fabricated cross-beams, with chains, screws and tightening nuts at either end. Each clamp can apply a force of up to 10 tonnes. The beams are usually at least 150 mm. longer than the width of the panel to allow room for attaching the retaining clamps. The retaining clamps and 'I' beams are usually spread some 200-300 mm. apart. Tightening the nuts with a special long handled torque wrench ensures equal pressure from clamp to clamp and assembly to assembly.

131. This operation is practical, extremely simple and efficient. Capital expenditure is very low, but, depending on curing conditions output may not be very high.

2. Hand Powered Presses

132. Quick acting, hand operated veneering presses are time honoured and very versatile. They are available in many sizes and normally deliver a pressure of up to 7 kg/cm^2. The frames are made of heavy section steel and the supporting surfaces are accurately planed to ensure true alignment. Movable bottom tables, which facilitate loading and unloading, are mounted on eccentrically operated supports and runners. They move easily in and out of the press and when more than one table is involved they can be coupled together or moved independently. The quick raising and lowering of the pressing screw can be achieved by a split nut mechanism. The nut is made of two parts which are brought in and out of mesh with the thread of the screw, by ball lever. When the pressing nut is out of mesh the spindle can be quickly raised and lowered by a hand wheel operated through bevel gears. These presses can be of the side or end-loading type.

3. Single Opening, Hydraulic-Operated Cold Presses

133. A further development from the hand operated presses has been the inclusion of hydraulic pressure aggregates. Down or up stroke types are available. Each pressing table is equipped with one or more rams and sometimes an additional ram for rapid opening and closing. These presses are easily loaded from the side; tables can be pulled out of the press and can be operated individually or together. Such machines are somewhat more expensive than hand powered models but they need no foundation work and are easy to operate and maintain.

b) Multi-Daylight Veneering Hot Presses

134. These are manufactured in a variety of sizes and pressing capacities to suit any volume of work. Here the pressure is exerted by hydraulic ram or rams, whilst heat is transferred to the glue-line from heated platens. Platens can be heated by resistance heating, by direct steam or hot water or indirect electric heating by means of water or oil flow heaters. The temperature of the platens is thermostatically controlled, the required temperature being set on a recorder which in turn is connected by thermo-couples to the platens to prevent heat losses. The selected temperature is governed by the type of adhesive in use, the curing time required and the depth of penetration needed to reach the glue-line. Pre-set pressure is maintained over the entire length of the curing cycle. These presses are normally loaded manually but if standard work pieces are continuously used, automatic loading devices may be employed. When hand loading multi-daylight presses, great care must be exercised to load and close the press as quickly as possible in order to avoid pre-cure of the glue-line.

135. Multi-daylight veneering hot presses normally do not require excavation for foundations. They are eminently suitable for medium sized plants, giving a much higher output than cold presses. There is, furthermore, a saving in space and the presses can be worked by only one or two operators.

c) Hot Pressing in Flow-Feed Single-Daylight Presses for Flat Surfaces

136. Progress in the development of fast setting synthetic glues has made it possible to reduce hot pressing times. Hand loaded multi-daylight hot presses are in many cases no longer economical since it is not possible to fully realise the short setting times of modern synthetic wood glues. Combining automatic feeding and operating with the use of fast curing adhesives, it is possible for a single-daylight press to exceed the output of a hand loaded multi-daylight press by up to 50%. A fast curing glue is therefore essential provided that its higher viscosity, shorter pot-life, and hence spreader life, are accepted. Such glue mixes have essentially a high resin solids content and a fast acting hardener. Economic considerations and field experience have clearly shown that flow-feed presses are superior to multi-daylight presses, especially where the distance to the glue-line is less than 1.5 mm.

137. Single opening hot presses can be supplied with down or upstroke pistons, platen widths of up to 2300 mm. and lengths of up to 7000 mm. They are normally designed for a specific pressure of up to 3 kg/cm^2. Most modern single-daylight presses require no operator since the press cycle, once adjusted, is fully automatic. The press platens can be heated up to about 150°C.

138.- The flow-feed presses are always equipped with a feed and offtake system. These automatic systems keep staff costs low. The press loading may be achieved by the use of:

- the tray belt system (Figure XIIa)
- the steel belt system (Figure XIIb)
- the plastic belt system (Figure XIIc).

Tray Belt System:

139. The tray belt comprises a conveyor belt on a moveable carriage. During the pressing cycle this remains outside the press allowing work pieces to be veneered and assembled on it. During this assembly work the belt can be moved forward, step by step, by means of a foot operated switch, until fully

loaded. After the press has opened, the carriage is fed into the press whilst, at the same time, the pressed parts are pushed out onto a roller conveyor by means of the front end of the tray belt. When the tray belt is withdrawn from the press the belt itself will start to move in the opposite direction. Withdrawal speed of the tray belt and the speed of the belt itself are synchronised in such a way that the parts on the belt are deposited onto the hot platen. A so-called transfer nose was supposed to ensure that the assemblies were not disturbed when being deposited. In practice it was found, however, that the work pieces slipped on the tray belt and on the hot platen. The advantage of this system is that the work pieces are assembled on a cold surface. However, the time required for the return journey of the tray, and also the extra daylight necessary to accommodate the tray, increased the total cycle time.

Steel Belt System and Modified Steel Belt System:

140. Here a steel belt is used to transport the press load. This is stopped during each pressing cycle and is only moved forward by one press length after completion of the cycle and as soon as the press has opened. The belt extends before and behind the press so that the material to be processed can easily be placed upon and/or taken off the belt. The disadvantage of this system is that the belt must be lifted to prevent it from rubbing against the press table. The daylight of the press has therefore to be increased by a corresponding amount. Furthermore, the steel belt has to be protected against excessive deformation due to heat. Replacement of a steel belt is time consuming and expensive.

141. Alternatively, a plastic belt conveyor can be arranged in front of the steel belt. This plastic belt can be moved forwards stepwise by means of a foot operated switch even during the pressing operation so that it can be loaded from a fixed point.

142. To load the press both belts are moved forward simultaneously so that the material is transferred from the plastic belt onto the steel belt.

Plastic Belt System:

143. This system is similar to the plastic-belt-modified steel belt loading device except that two endless plastic belts are used, there being no problem when transferring assembled work pieces from the loading belt to the belt in the press. It has been claimed that plastic belts will withstand up to 10,000 pressings at a press temperature of 130°C., at higher temperatures the life span of the plastic belt is, however, reduced. The plastic belts are cheap and replacement is achieved in a few minutes.

144. The space required for these plants is relatively small even when the glue spreader is included. The glue spreader is an essential part of such a production line. Moreover the complete line is easily accessible from all sides. Veneering in such flow-feed presses is very economical since there is a good production flow, a low space requirement, short pressing cycle, low staff requirements and short idle times. In the case of veneering particleboard with 0.6 mm. thick veneer up to about 60 pressings per hour can be achieved. Capital expenditure is, however, fairly high and maintenance has to be done by well-trained mechanics.

d) Ratchet or Hydraulic Pressing of Shaped Articles

145. The shaped forms or moulds may be made of wood or metal but in both cases they must be most carefully prepared to give the exact contour. If only a small number of shaped articles is to be veneered it is cheaper to use plywood moulds and bond the veneer onto the substrate using cold setting adhesives. Pressure can either be applied in a hand or hydraulically operated cold press as described above.

146. If a large number of articles is to be fabricated, such as chair backs or seats, (or work in which the prime cost of the mould can be absorbed into the contract price of the finished object) it is advisable to use specially prepared steel or metal moulds in multi-daylight, hydraulically operated hot presses of the type mentioned under 3b. It is essential

that pressure distribution is even over the entire surface area of the mould. Such special presses are usually fairly expensive and the moulds need careful attention.

e) Vacuum and Dome Process

147. Another method of veneering curved pieces is the use of vacuum and dome presses. A flexible sheet enables pressure to be exerted perpendicular to the surface and is thus more versatile in its application by comparison with a rigid, curved platen. The principle embodied in vacuum or dome presses is illustrated diagramatically. (Figure XIII.)

148. In the vacuum press, vacuum is applied beneath a flexible sheet covering the work piece, in the dome process additional positive pressure is applied to the other side of the sheet. The use of vacuum alone necessarily limits the pressure on the work piece to a value which in some applications is too low to produce satisfactory glued joints. In this case it is necessary to apply a positive pressure.

149. A vacuum press consists basically of a table-top covered by a rubber sheet which can be clamped around its edges or sealed down. Air is withdrawn from beneath the sheet by vacuum pump. The table-top may be heated by steam, hot water or electricity. Modern vacuum presses are designed in such a way that one work piece can be assembled while waiting for the previous one to cure. These twin vacuum veneering presses have very few wearing parts and maintenance is a simple matter. They are suitable for continuous production.

150. In the dome press a positive pressure is used. Here a flexible bag is inflated and its expansion is restrained by confining it inside a metal dome; its lower surface bears on the work piece, thus applying pressure. The bag can be heated by infra red heaters.

(iv) Edge Lipping and Banding Machines (31.4)

151. Edge lipping and banding are important processes in furniture and door manufacture. Compared with other methods of finishing raw edges, such as painting, veneering and lipping give a superior standard of finish but are in general more costly. The simplest method of finishing the edges is by means of pressing jigs and clamps. This operation is, however, labour intensive and the automatic machines that have been developed offer a large saving in labour cost, especially in high volume production, e.g. doors, where any reduction in the cost of this process is quite important. The principles in edge lipping and banding are fundamentally identical, the difference in the terminology being one of thickness and flexibility of the strip. Edge banding is the bonding of flexible, thin wood veneers or plastics while lipping refers to rigid, thick strips.

Clamps With or Without Heating

152. One method of veneering edges is similar in principle to that used for face veneering. A thermosetting UF glue is applied to the edge of the panel by brush or hand-roller, the panel is then placed in a jig, the strip of veneer inserted and pressure applied mechanically by clamps. The frame of the gluing stand is made of metal channel sections bolted together. It is equipped with manually operated pressure units that can be adjusted to any desired point on the rails by means of screw clamps. Brackets forming the fixed stops can be secured in any of several positions so that the work can be handled at the most convenient height depending on the size of the component. Such gluing frames are obtainable as single or rotating units, with three or more sides providing an increased gluing capacity, or as permanent installation against walls. All these units can also be equipped with electric heating bars and holders thus reducing the clamping time and increasing output. Such gluing jigs are inexpensive and will prove an economical proposition in even the smallest joinery shop. Normally these frames can be loaded from two sides at any convenient height thus enabling work to progress continuously. Pressure can be controlled easily. The stands occupy little space and are quickly adjusted. The equipment is equally suitable for edge lipping.

153. Another type of machine uses valve controlled pneumatic pressure cylinders. The jig is capable of edging panels up to 3000 mm. by 850 mm. The preparation of strips is facilitated by a built-in circular saw. This arrangement eliminates the necessity of cutting the strips to the required width before gluing. Also a complete sheet of veneer or plastic may be fed into the machine. This makes it possible for the veneer grain to run vertically. i.e. at right angles to the edge. A vertically supported electric heating bar can be adjusted to a temperature of up to 180°C. Cycle times of 20 seconds and 50 seconds are obtained for wood veneer and plastics respectively. Solid wood lipping can also be carried out provided that the lippings are preheated. Furthermore, in practice, it has been found that very long, solid wood strips are usually buckled and distorted. For this reason an edge pressing device has been developed which serves to straighten distorted solid wood strips prior to pressing up. This attachment is operated pneumatically through a hand valve.

154. A very effective and highly practical method of edge veneering is the use of low voltage heating (LVH). (Figure XIV) When an electric current passes through a conductor, heat is generated. The amount of heat is dependent, amongst other factors, on the resistance of the metal, which, in turn is related to its length and cross-section. Thus, in this heating method a robust metal element has its temperature raised by having a high current at a low voltage passed through it. This current is obtained from a step-down transformer and carried to the element by means of heavy duty cables. This method is suitable for edge banding with both wood and plastics strips. Basically, the edge banding medium is brought into contact with the hot element and heat is conducted from this to the glue-line, thus accelerating curing. The usual veneering pressure of 2-5 kg/cm^2 can be obtained by using a jig with air cylinders.

155. The power from the mains to heat 4800 mm. of 25 mm. wide element is approximately 0.5 kW/h. An area of 1220 x 610 mm. uses approximately 2kW/h. The initial capital outlay for a low voltage heating unit plus a suitable home-made jig is not more than £100. The unit needs little maintenance

other than replacement of the heating element. Curing time depends on the distance from the element to the farthest glue-line.

156. Where the heat has to penetrate 1 mm. or more to the glue-line it is generally more economical to use radio frequency (RF) curing.

157. Basically, when two metal plates or electrodes separated by a non-metallic substance are connected to a radio frequency voltage, heat is generated in the material itself due to dipole movement. In general this phenomenon occurs at all frequencies, but for industrial purposes, the frequencies have to be stepped up to several million Hertz, normally 10 MHz (10 megacycles). The normal power supply is fed into the RF generator which steps up the voltage and frequency; the jig, which is tuned to the frequency of the generator, takes power and a high frequency field is created between electrodes suitably placed in the jig. There are three methods currently in use for the application of RF fields. They are:

1. Transverse heating
2. Stray-field heating
3. Glue-line heating.

158. This latter is the most efficient way of applying RF to assemblies and is normally used in the lipping process. The electrodes are on either side of the glue-line. (Figure XV) This means that only the glue is raised to a high temperature and cures in a very short time. The position of the electrodes is a most critical factor in achieving correct results, as it is necessary to induce power selectively into the glue-lines. Ingenuity and precision in the construction of suitable jigs is called for since if the glue-line is not under pressure the water in the glue will boil giving a foamed glue-line which has no strength. When only the two opposite edges of a panel have to be lipped, side pressure is exerted by means of an inflated air hose which is normally held flat but rises to become cylindrical when the air is forced into it. In tending to become cylindrical it exerts a thrust onto a pressure member which in turn transfers it to the lipping. The other side of the press has a rigid pressure

member which is held against adjustable supports. Two down pressure units acting on the lippings and edges of the panel are also air hoses.

159. The down pressure, as well as making certain that the lippings and edges are flush, ensures that the electrodes are in contact with the glue-lines. In a typical two-edge lipping press capable of taking 2000 mm. long panels 18 mm. thick at 12% moisture content and using a suitable UF glue, curing times of 15-20 seconds can be obtained from a 4 kW generator. Assuming a total cycle time of 25 seconds, 240 cycles per hour can be achieved. Equipment is also available using the above principle, for simultaneous application of lippings to all four edges of panels. The advantages of RF lipping are thus:

1. Glue-line is heated selectively
2. Work piece and lipping are not heated
3. Very efficient method with high output
4. Damage or deformation of work piece or lipping unlikely.

160. The disadvantages may be summarised as:

1. RF generators are expensive
2. RF generators and jigs must be installed and maintained by suitably qualified personnel
3. All metal parts of jigs must be kept well clear of the RF field
4. Electrode positioning is critical
5. Danger of arcing due to the combination of air gaps and glue squeezed out
6. Power input varies due to variation in type of glue and glue spread
7. Frequent cleaning of electrodes is essential.

161. The use of low voltage heating for edge veneering and radio frequency for edge lipping certainly increased outputs but this still left room for the development of really high-speed production units.

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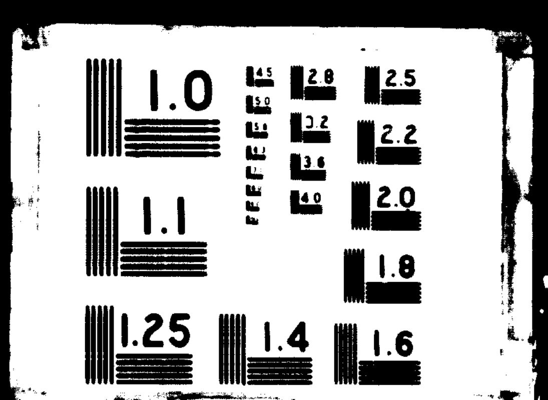

Continuous Edge Banding Equipment

162. The development of high-speed production equipment was made possible by the use of hot-melt adhesive which itself was a significant innovation in the field of gluing. Normally, automatic edge banding machines work on the hot/cold principle i.e. the molten adhesive is spread on the panel edges by means of glue applicators. The wood veneer, plastics strip or lipping, is continuously fed and pressure rollers force the strips onto the panel's edge. The glue-film cools down and sets at the same time, thus forming the bond between the work-piece and the lipping. Once the basic machine for continuously applying edgings had been developed it was not long before further refinements such as double end tenoners, top and bottom trimming saws, flush trimming cutterheads, sanding devices, bevelling sanders and buffing units were added. Thus, the latest machines combine multiple operations in one unit. There are now many sizes and types of machine on the market to suit virtually all requirements. With the unit system employed in producing edge banders and the number of different units available, the customer can obtain a machine to suit his specific requirements. It is thus possible to purchase the basic machine and then add the necessary optional units as and when they are required.

163. Edge banders are available as either single or double sided units or both, and some machines are designed for edging shaped work-pieces but cannot edge sides and ends simultaneously. Alternatively, machines can use preglued edging strips, the glue being reactivated by a hot air stream just prior to the pressure application. The thickness of edging acceptable may vary from 0.2 to 30 mm. and output rates of up to 40 meter/minute.

164. Finally, it should be mentioned that whatever edge bander is chosen it is the glue-line quality that determines the success or failure. When using hot-melts the temperature control in the glue pot is of vital importance. The water resistance of a hot-melt glue-line (in kitchen furniture for example) has been found to be inadequate. There has

therefore been greater interest recently in continuous edge banders that use hot-curing glues, e.g. crosslinking PVAc and UF. These machines feed panels, glue the edges and apply the lipping in a similar way to hot-melt machines. Instead of a cooling roll, however, the assembly passes between induction-heated steel bands which also exert pressure. Economic output, however, can only be attained with relatively thin edgings (say 1.5 - 2.0 mm.). Either wood, or plastics edge-strips can be used.

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General — For specific information on the construction and performance of particular machines, reference should be made to the extensive trade literature available from manufacturers.

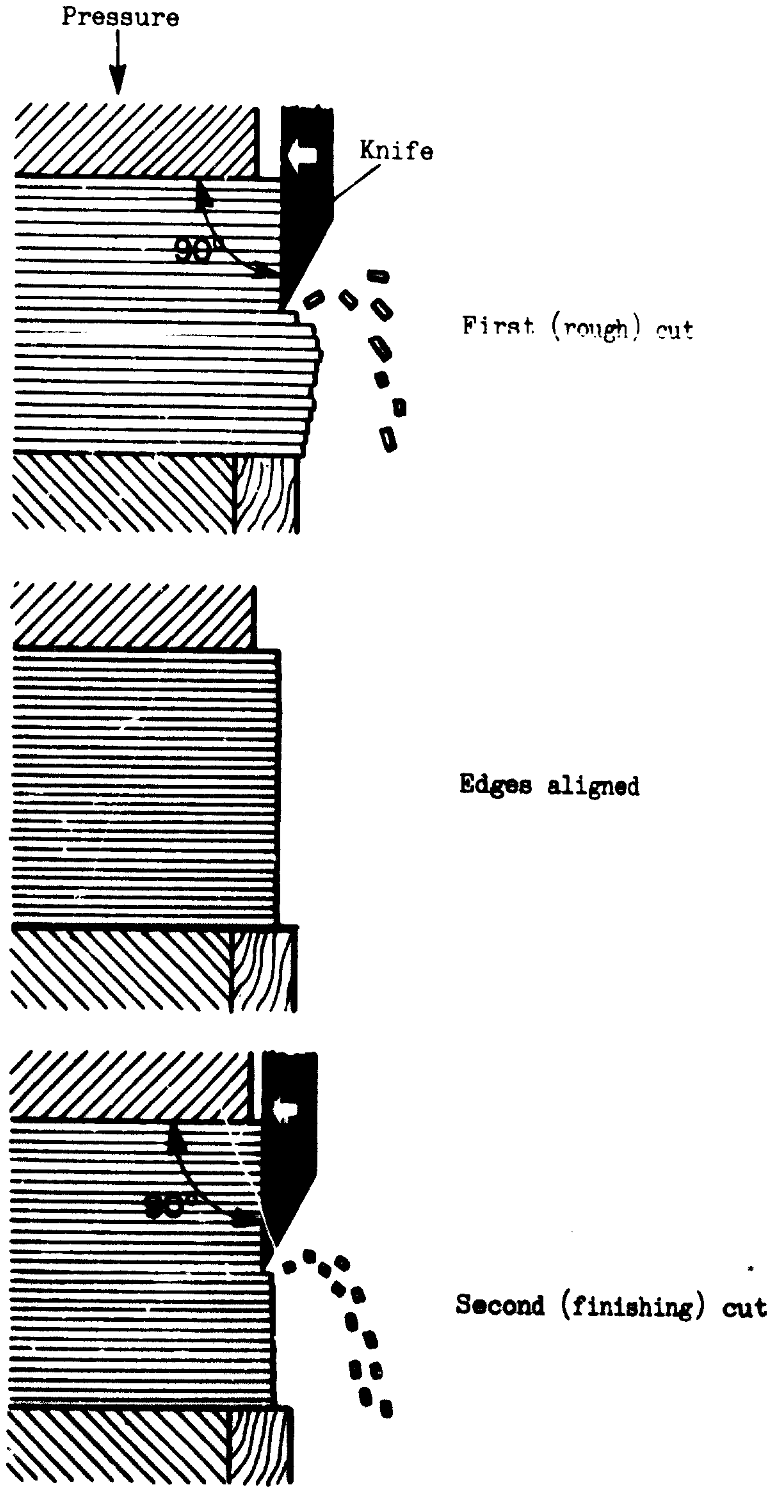

FIGURE I

TRIMMING VENEERS FOR EDGE JOINTING

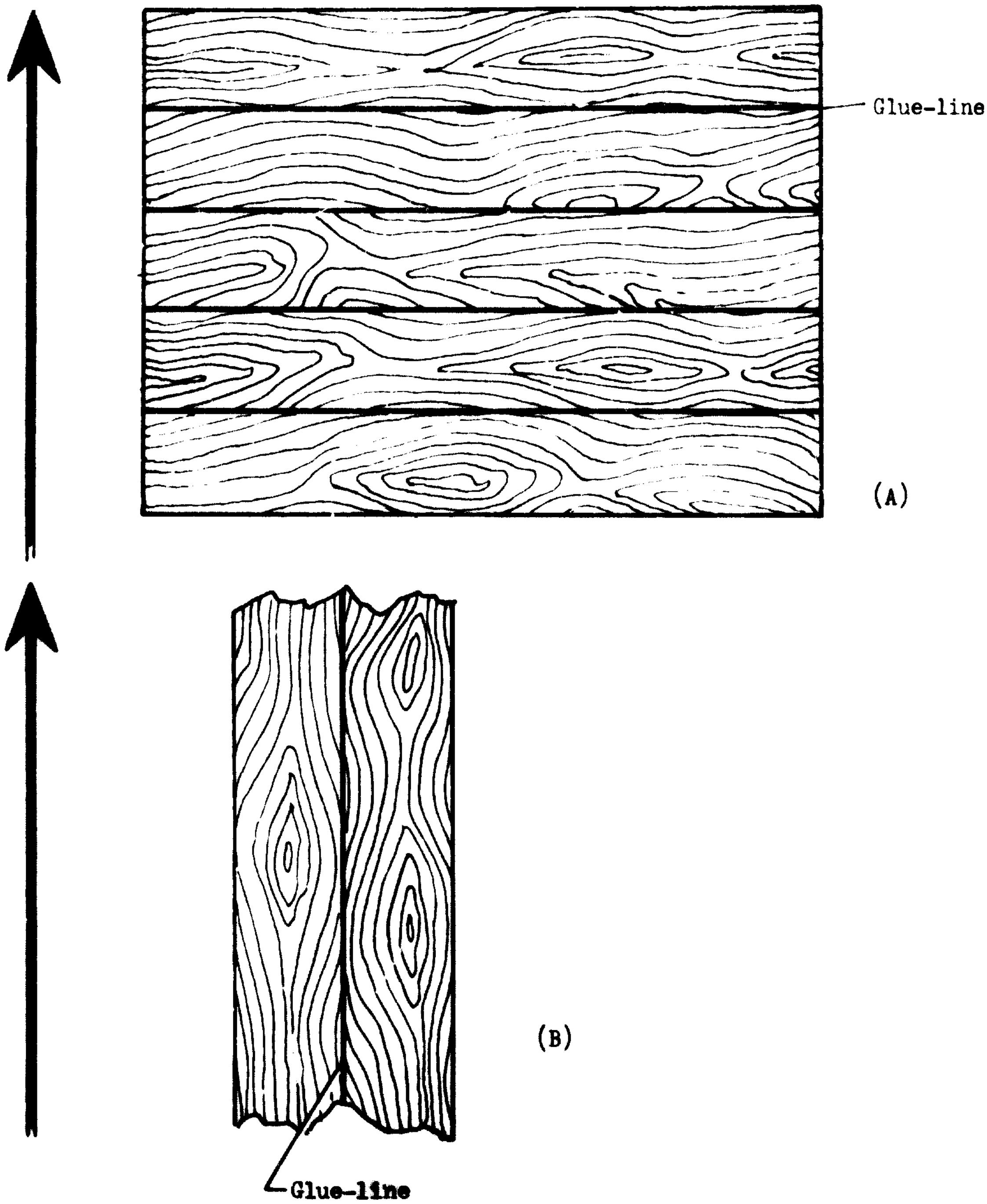

FIGURE II

METHODS OF VENEER JOINTING: (A) CROSS-FEED SPLICER
(B) TAPELESS VENEER SPLICER

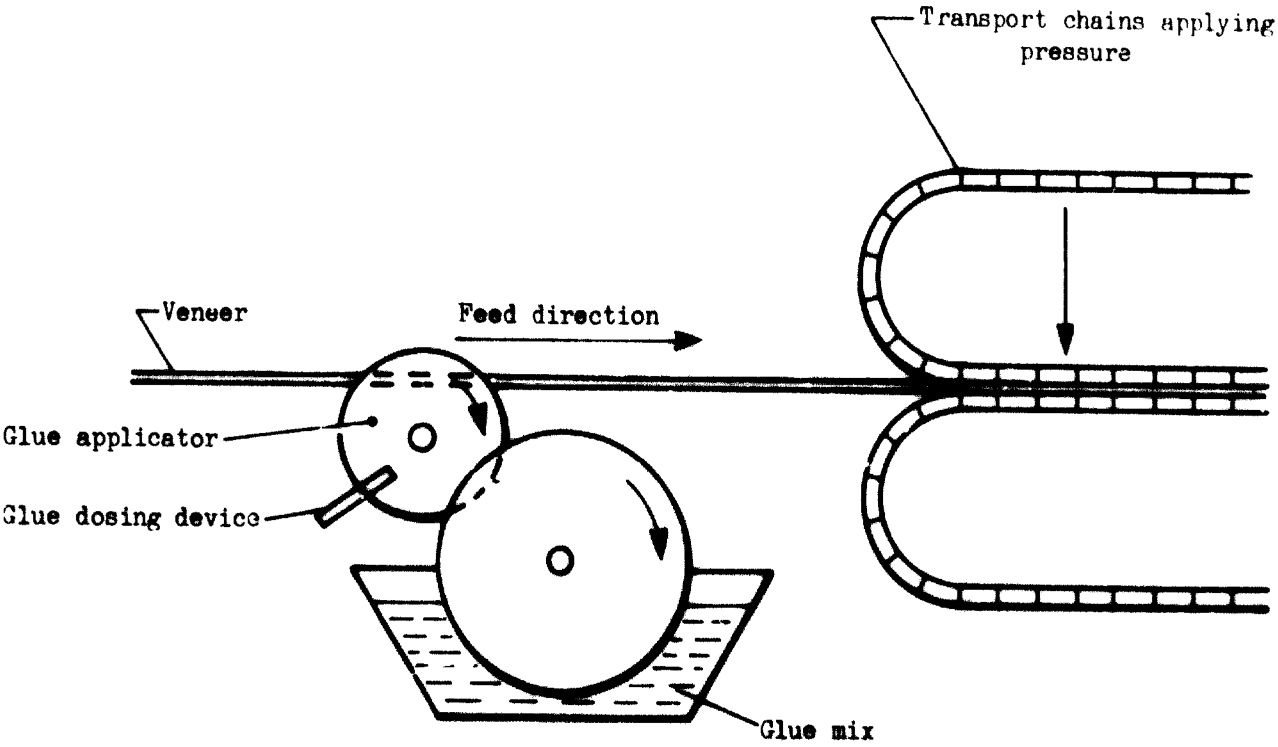

FIGURE III

GLUE APPLICATION IN TAPELESS VENEER SPLICER

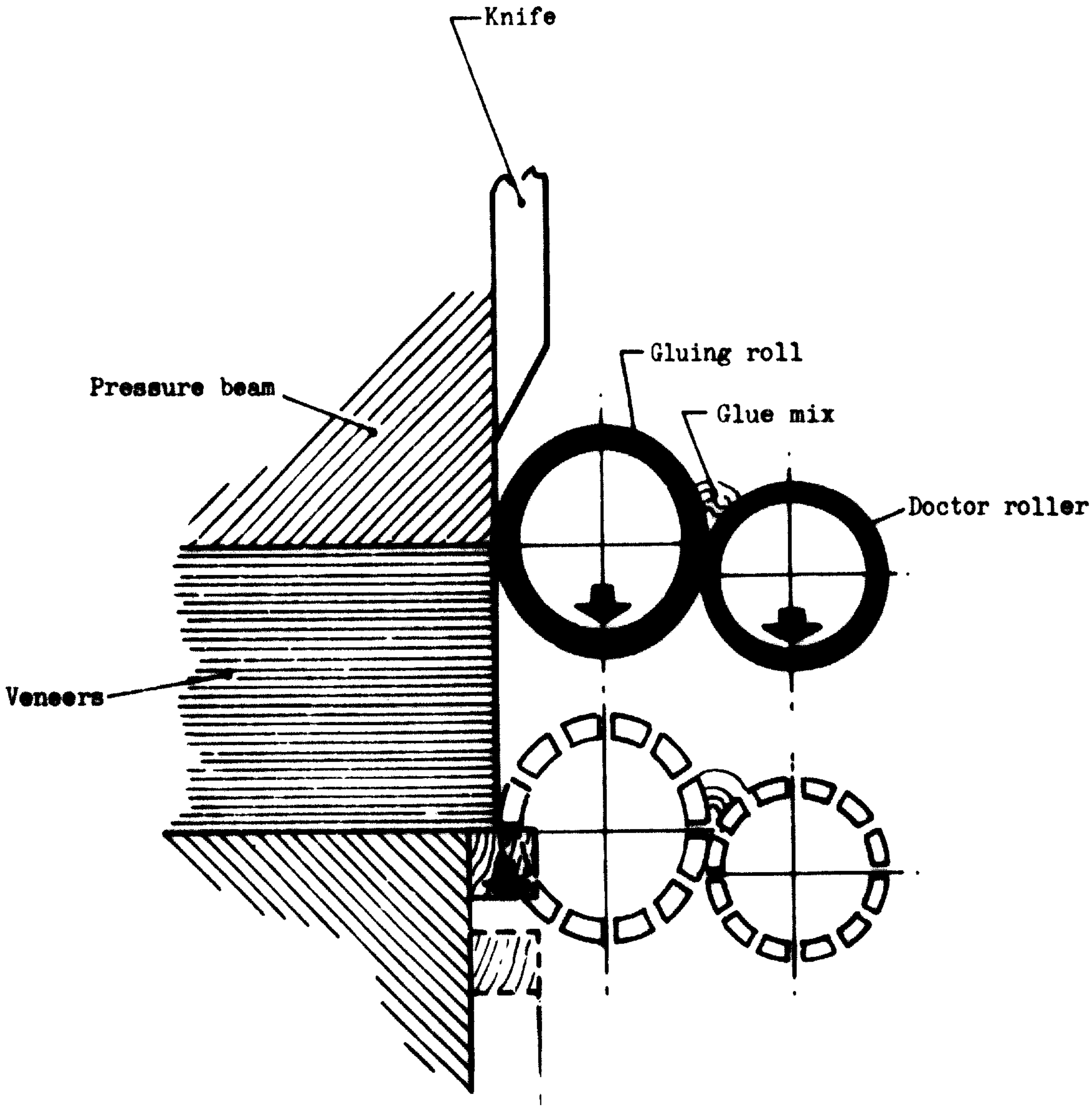

FIGURE IV

APPLICATOR FOR EDGE GLUING OF TRIMMED VENEERS

Top heated pressure bar open, closed as indicated by dotted line

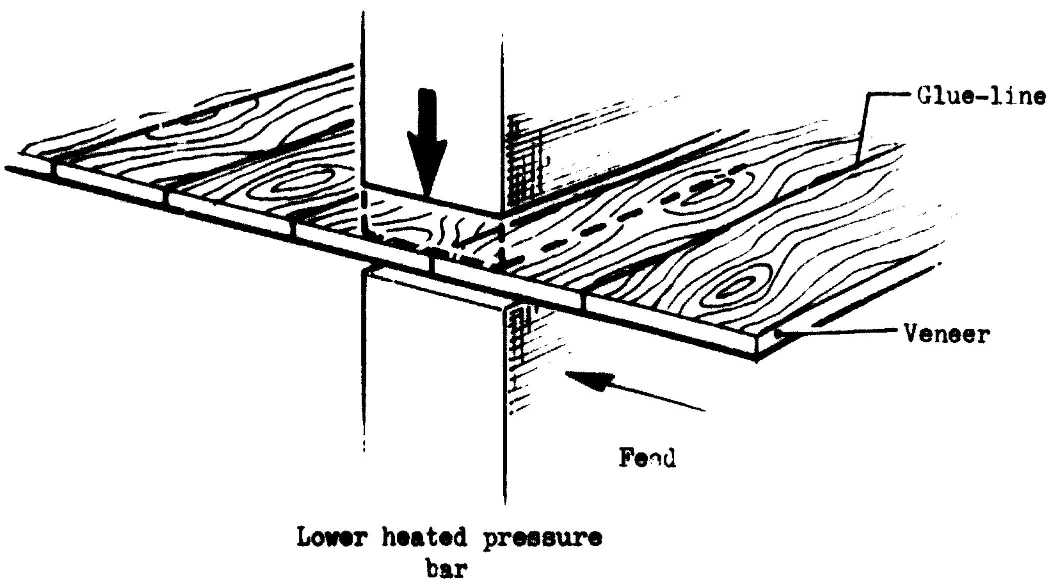

FIGURE V

DISCONTINUOUS VENEER SPLICER

FIGURE VI

CROSS FEED INTERWEAVE CORE SPLICING - ARRANGEMENT OF ADHESIVE AND THREADS

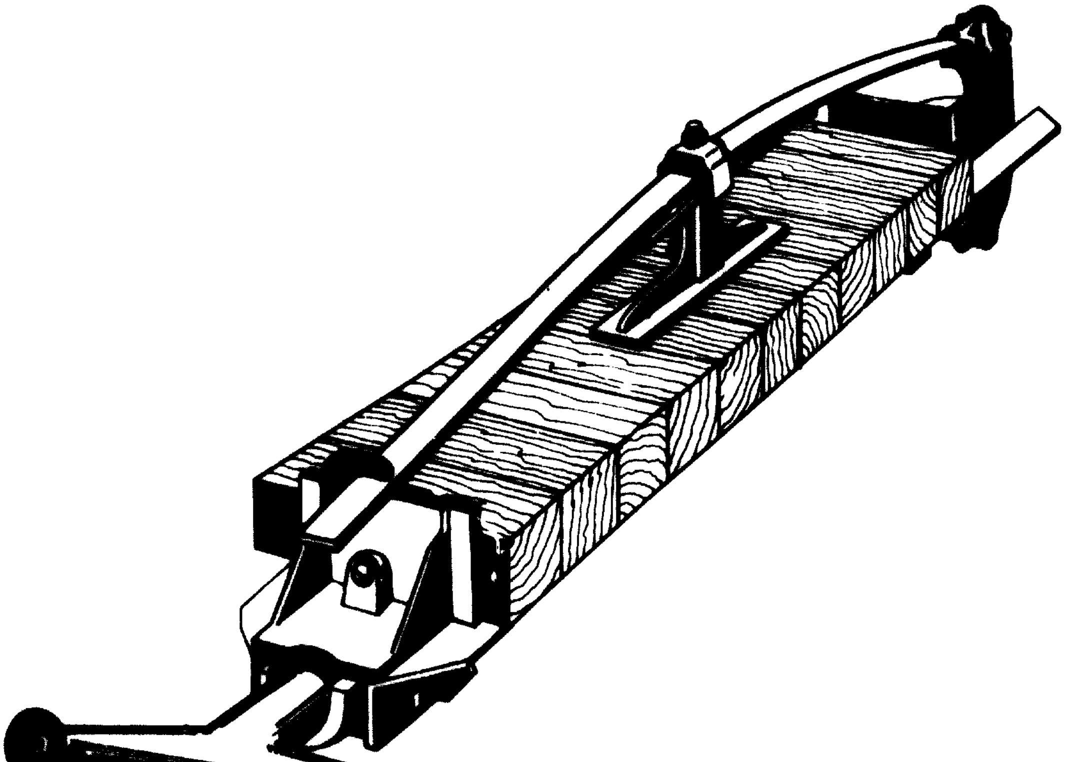

FIGURE VII

WIDE CRAMP FOR EDGE-JOINING BOARDS FITTED WITH DOWN-PRESSURE DEVICE TO RESTRAIN BOWING

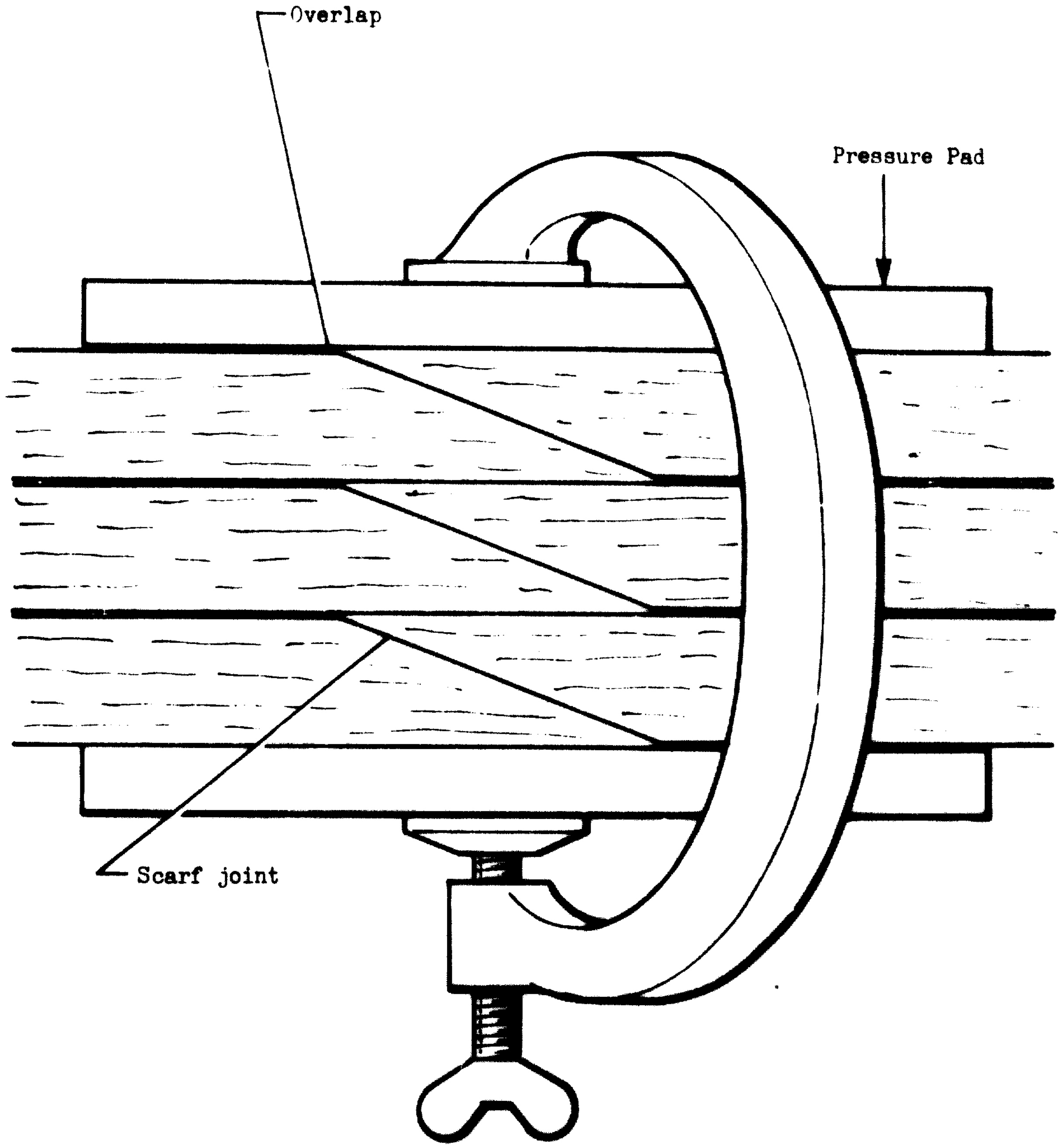

FIGURE VIII

CLAMPING ARRANGEMENT FOR SCARF-JOINTED LUMBER SHOWING OVERLAPPING ENDS OF JOINTS

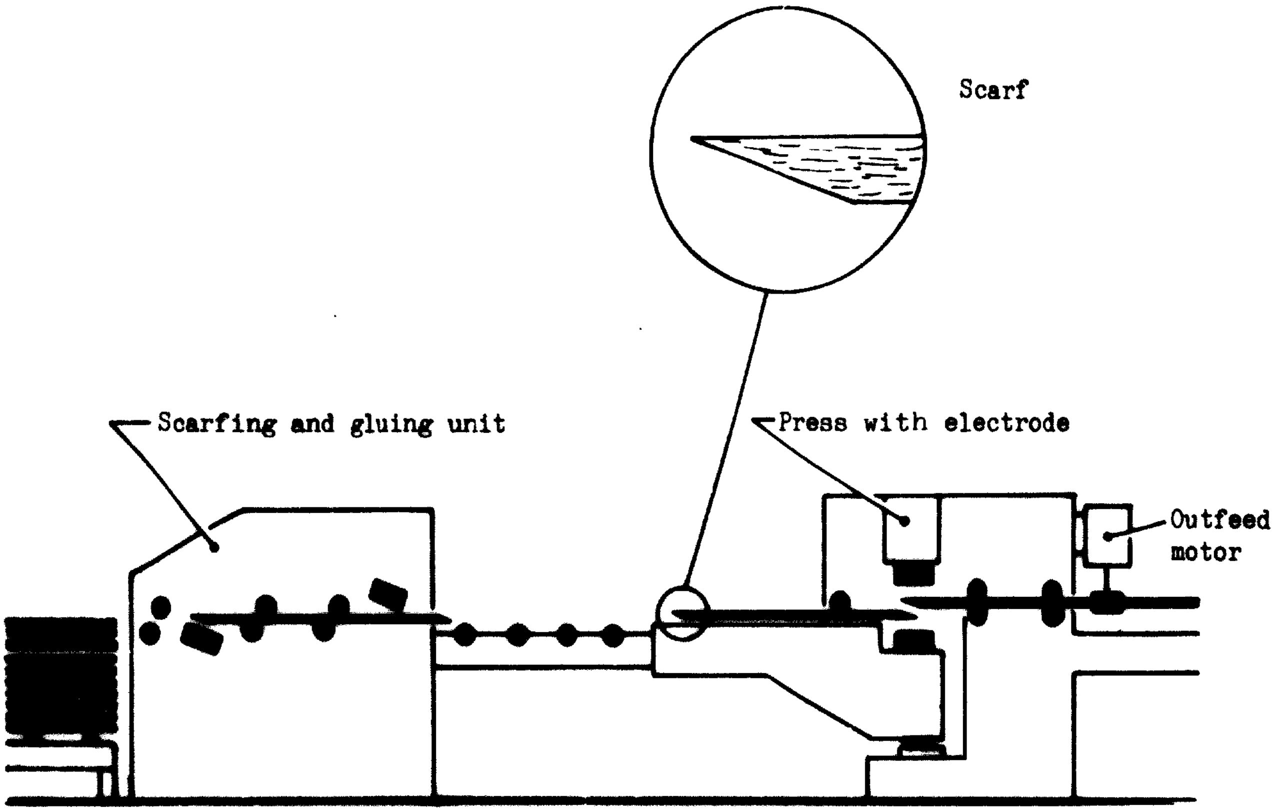

FIGURE IX

AUTOMATIC SCARFING OF SHEETS

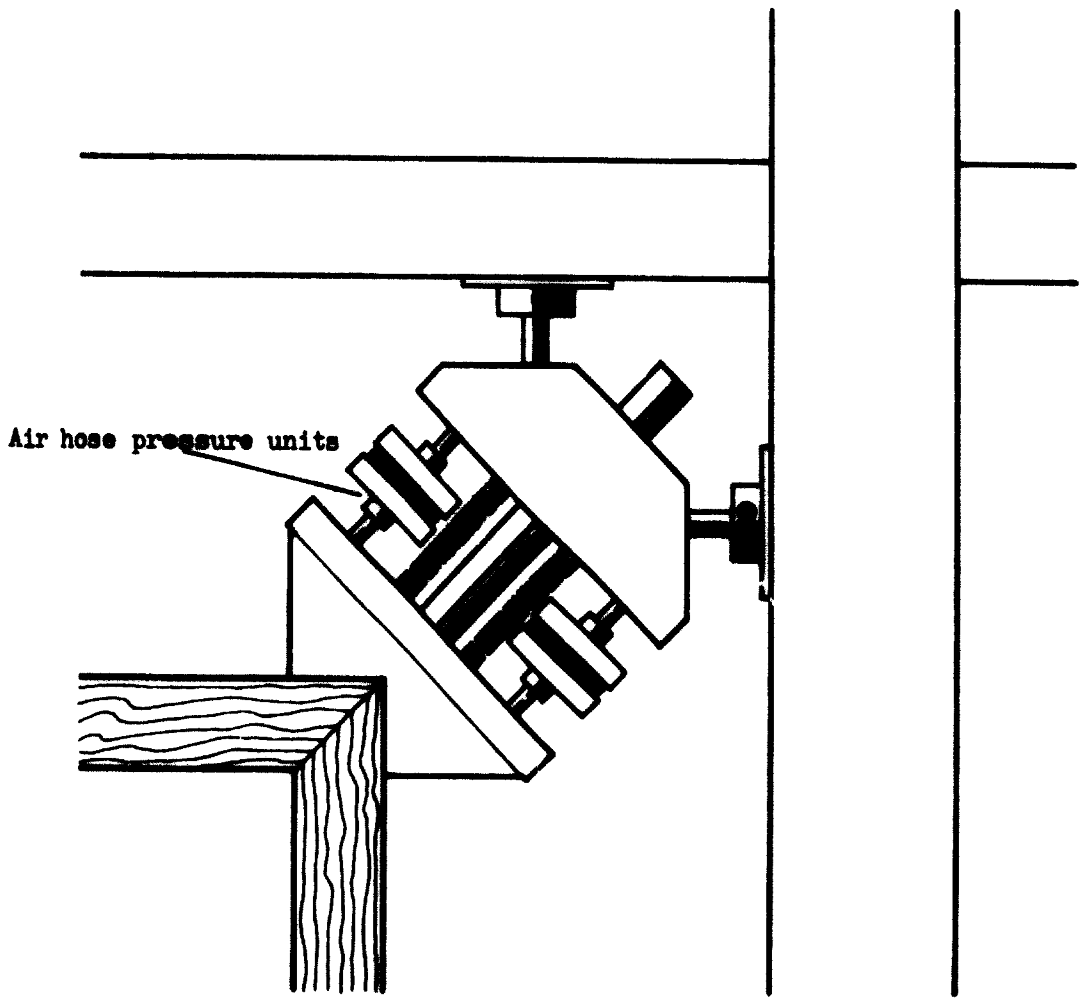

FIGURE X

PRESSURE UNIT FOR CARCASE CRAMP SHOWING 'V' BLOCK FOR ACCURATE LOCATION OF MITRED CORNER

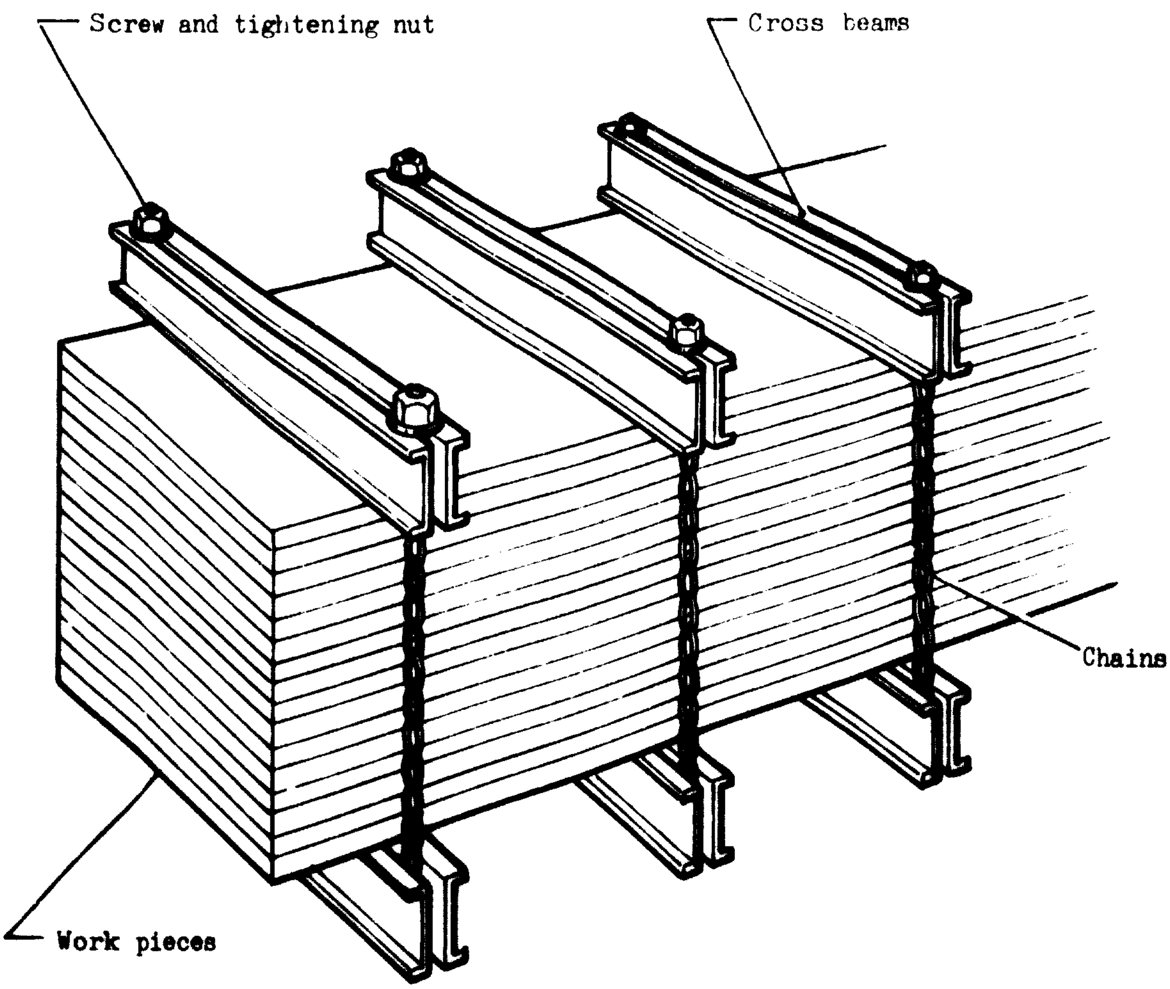

FIGURE XI

RETAINING CLAMPS FOR COLD PRESSING

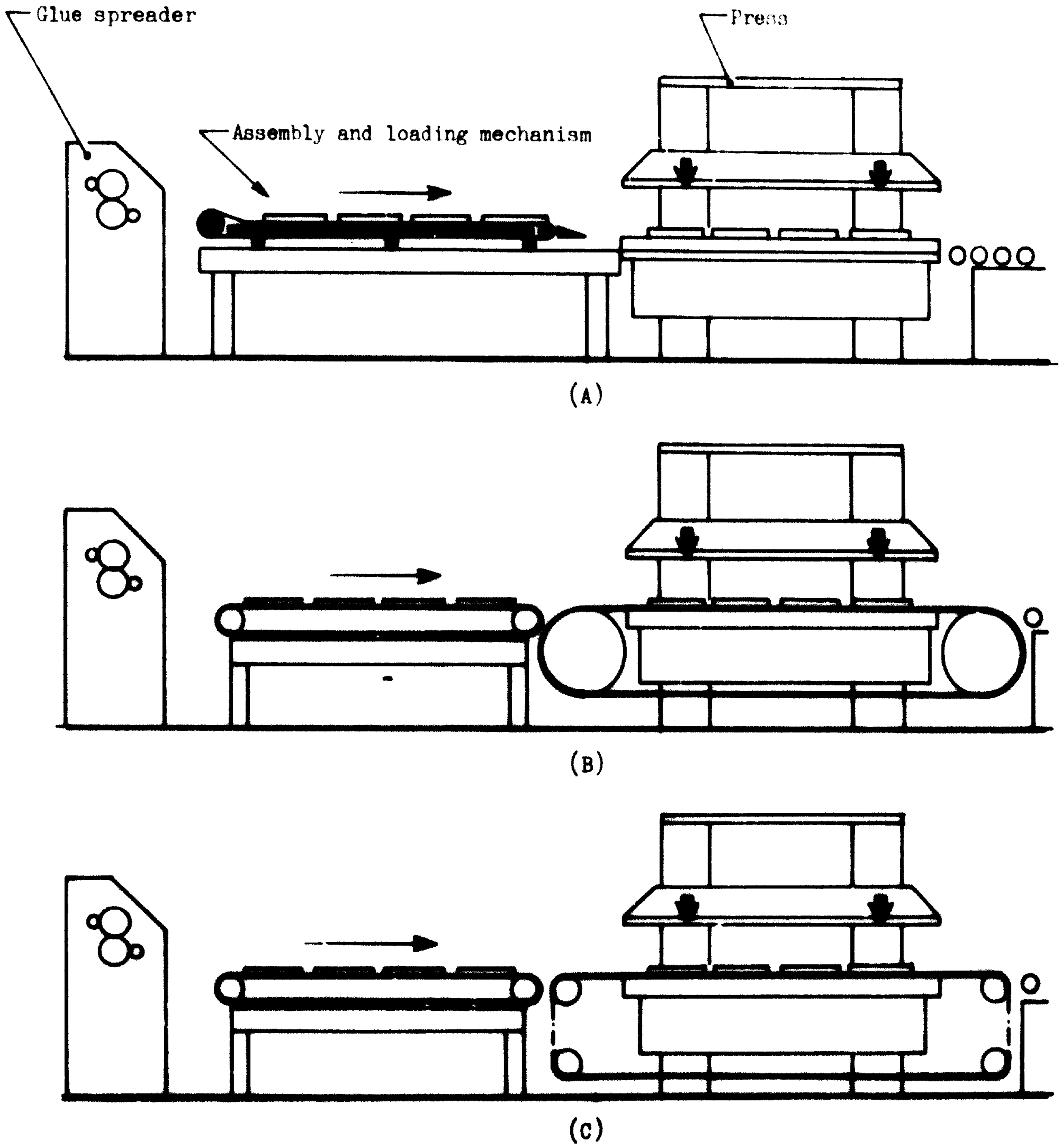

FIGURE XII

FLOW-FEED PRESSES WITH VARIOUS LOADING MECHANISMS:

(A) TRAY BELT

(B) STEEL BELT (MODIFIED)

(C) PLASTICS BELT.

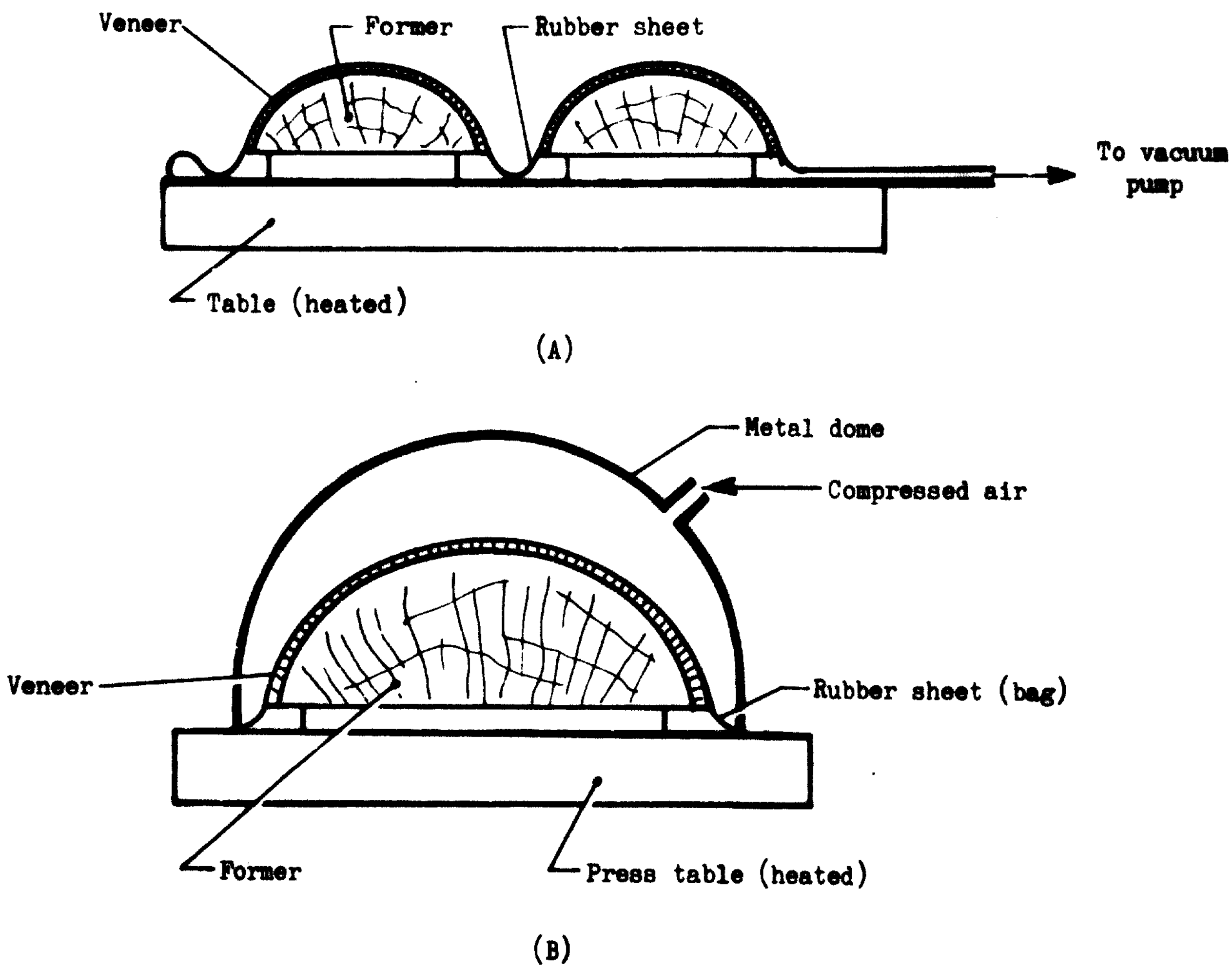

FIGURE XIII

VACUUM (A) and DOME (B) PRESSING

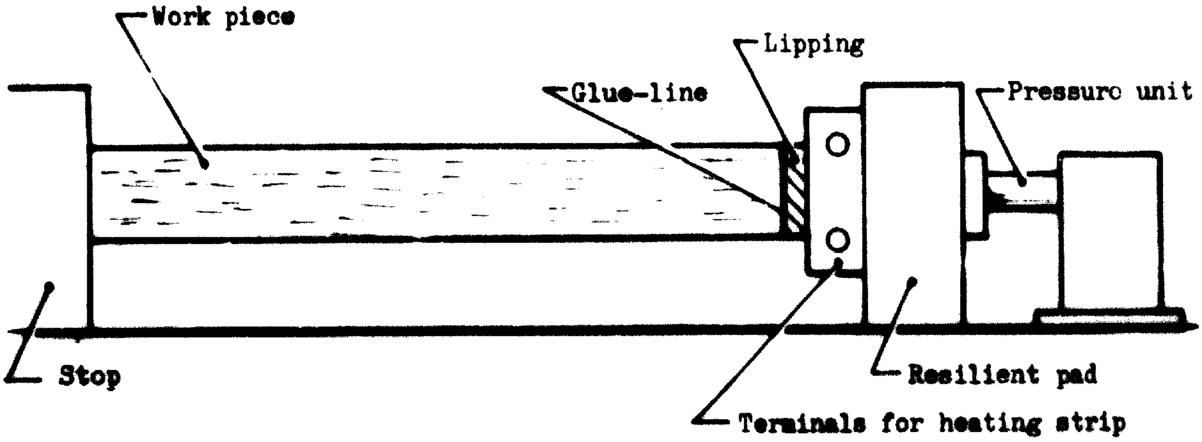

FIGURE XIV

EDGE LIPPING USING LOW VOLTAGE HEATING

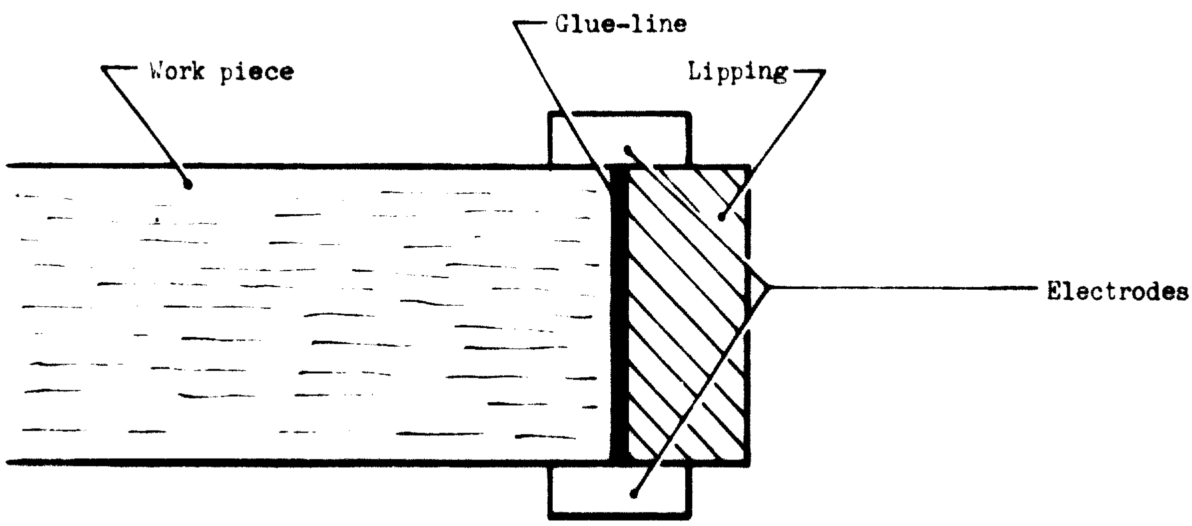

FIGURE XV

ELECTRODE ARRANGEMENT FOR RADIO FREQUENCY GLUE-LINE HEATING

74.09.11