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Technical Meeting on the Selection
of Woodworking Machinery

Vienna, 19-23 November 1973

SELECTION OF EQUIPMENT AND PRESERVATIVES FOR WOOD PRESERVATION[1/]

by

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Organización de las Naciones Unidas para el Desarrollo Industrial

Reunión técnica sobre selección de maquinaria
para trabajar la madera

Viena, 19 - 23 noviembre 1973

SELECCION DE EQUIPO Y DE AGENTES PROTECTORES PARA LA CONSERVACION DE LA MADERA[1]

por

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Ascu Hickson Limited
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RESUMEN

En la presente memoria se reseñan los diferentes tipos de procesos, equipo y agentes protectores que actualmente se emplean, y se examinan los pros y los contras de cada uno de ellos, con el fin de ayudar a los industriales de los países en desarrollo a buscar la mejor solución para los problemas que se les planteen en relación con la conservación de la madera.

Los cuatro tipos de procesos son los siguientes: proceso de impregnación a presión, al vacío, sin presión y por difusión. A veces es necesario preparar y acondicionar la madera antes de su tratamiento secándola por varios métodos, tales como al vapor y al vacío. Conviene que la madera se trabaje lo más posible antes de su tratamiento.

Los procedimientos a presión permiten un alto grado de control de la labor de conservación; si bien los procesos que se desarrollan sin presión, en frío y en caliente, se aproximan al rendimiento y grado de control de aquéllos. La creosota es

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

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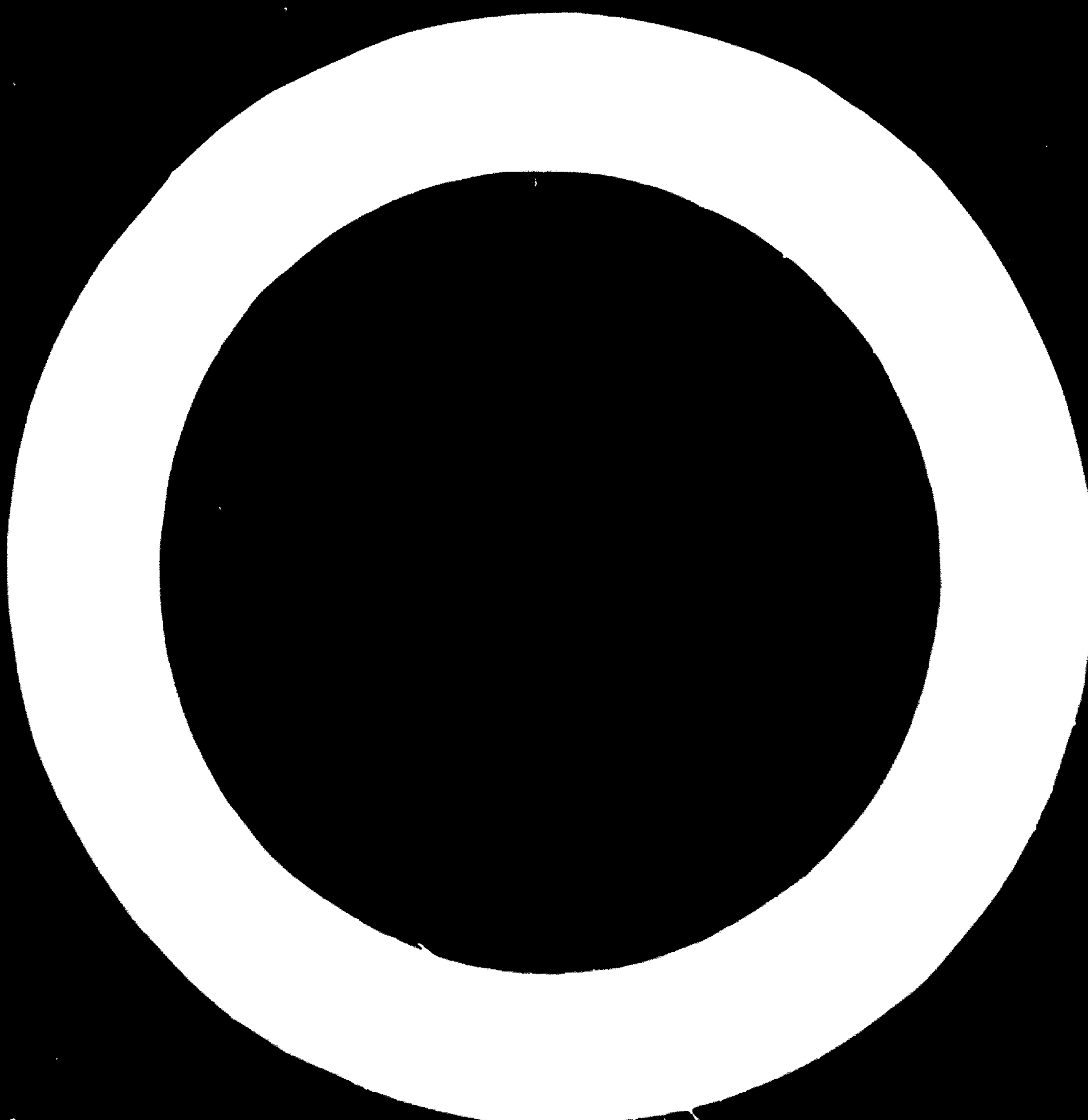

especialmente apropiad[illegible] ... brocha
inmersión y [illegible] ... temporal.

[illegible] los procesos de [illegible] ... célula va[illegible] y método [illegible] ... que suele dar altos coeficientes de retención y de penetración.

Los procesos por difusión requieren [illegible] y consisten en un intercambio de iones [illegible] (método [illegible]) ... aplicación de presiones bajas (procedimiento Boucherie).

La capacidad de [illegible] instalaciones de tratamiento bajo presión con calor puede variar de [illegible] m[illegible] a [illegible] m[illegible] por carga; el tratamiento de cada carga demora unas cuatro horas. Estas instalaciones requieren los servicios de un operario experto en calderas y mucha supervisión. Se dan informaciones adicionales sobre especificaciones técnicas, mano de obra y mantenimiento.

Las complejidades del proceso antes indicado se evitan principalmente utilizando el tratamiento bajo presión sin calor, ya que las bombas de presión suelen ser menos complicadas que el equipo de tratamiento al vapor. La instalación varía entre 1 m y 2,5 m de diámetro, tiene capacidades de 150 m^3 a 200 m^3 por carga (con un período de tratamiento de unas cuatro horas) y se presta para modelos móviles.

Los métodos de extracción por disolventes son relativamente nuevos y sirven para maderas refractarias, pero requieren un equipo complejo y un personal más especializado para su operación y mantenimiento.

El tratamiento al vacío, en el que se aplica una presión diferencial de aproximadamente 1 kg/cm^2 y suele utilizarse pentaclorofenol, resulta muy útil para elementos de ebanistería, en los que es preciso que la madera quede seca y lista para el uso.

El tratamiento sin presión, en frío y en caliente, requiere el empleo de antisépticos a base de aceite (como creosota) y es relativamente seguro y fácil de aplicar. Los rociadores de túnel son eficaces para el tratamiento profiláctico en gran escala de durmientes. El equipo es simple y para su manejo y mantenimiento se requieren conocimientos elementales.

El control de calidad comprende principalmente pruebas de retención y profundidad de la penetración, deberá formar parte integrante de la instalación propiamente dicha.

Por último, se describen los tres tipos principales de antisépticos, a saber: las sustancias impregnantes a base de aceite (creosota), las sustancias acuosas (compuestos de cobre, plomo, arsénico) y los preparados a base de disolventes (pentaclorofenol). La aplicación de la creosota está muy extendida: esta sustancia posee buenas características impermeabilizantes, pero tiene un olor desagradable y presenta riesgo de incendio inmediatamente después del tratamiento. Los antisépticos acuosos protegen contra una gran variedad de insectos y agentes biodegradantes y se utilizan para torres de enfriamiento, durmientes, postes, instalaciones marinas y mineras y, sobre todo, para la madera destinada a la construcción, ya que tales sustancias son limpias e inodoras, y resulta posible pintar y pulir las superficies sin demora después del tratamiento. Los antisépticos a base de disolventes permiten trabajar con limpieza y eficacia, pero requieren una industria de productos químicos orgánicos bastante compleja para la producción del pentaclorofenol.

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Vienna, 19-[illegible] November 197[illegible]

SELECTION OF EQUIPMENT AND PREPARATIVES FOR WOOD PRESERVATION 1/

by

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SUMMARY

This paper outlines the different types of processes, equipment and preservatives in use today and considers the pros and cons of each to aid industrialists in developing countries to select the best solution to their wood preservation problems.

The four types of processes are pressure, vacuum, non-pressure and diffusion. Pre-treatment and conditioning sometimes are necessary and consist of drying by various methods, steaming and vacuuming and boiling under vacuum. As much carpentry work as possible should be done beforehand.

Pressure processes afford a high degree of control over the preservation work, but the hot and cold non-pressure process approaches their performance and controlability. Creosote is particularly appropriate for this method. Brushing, dipping and spraying are more suitable for temporary or limited protection.

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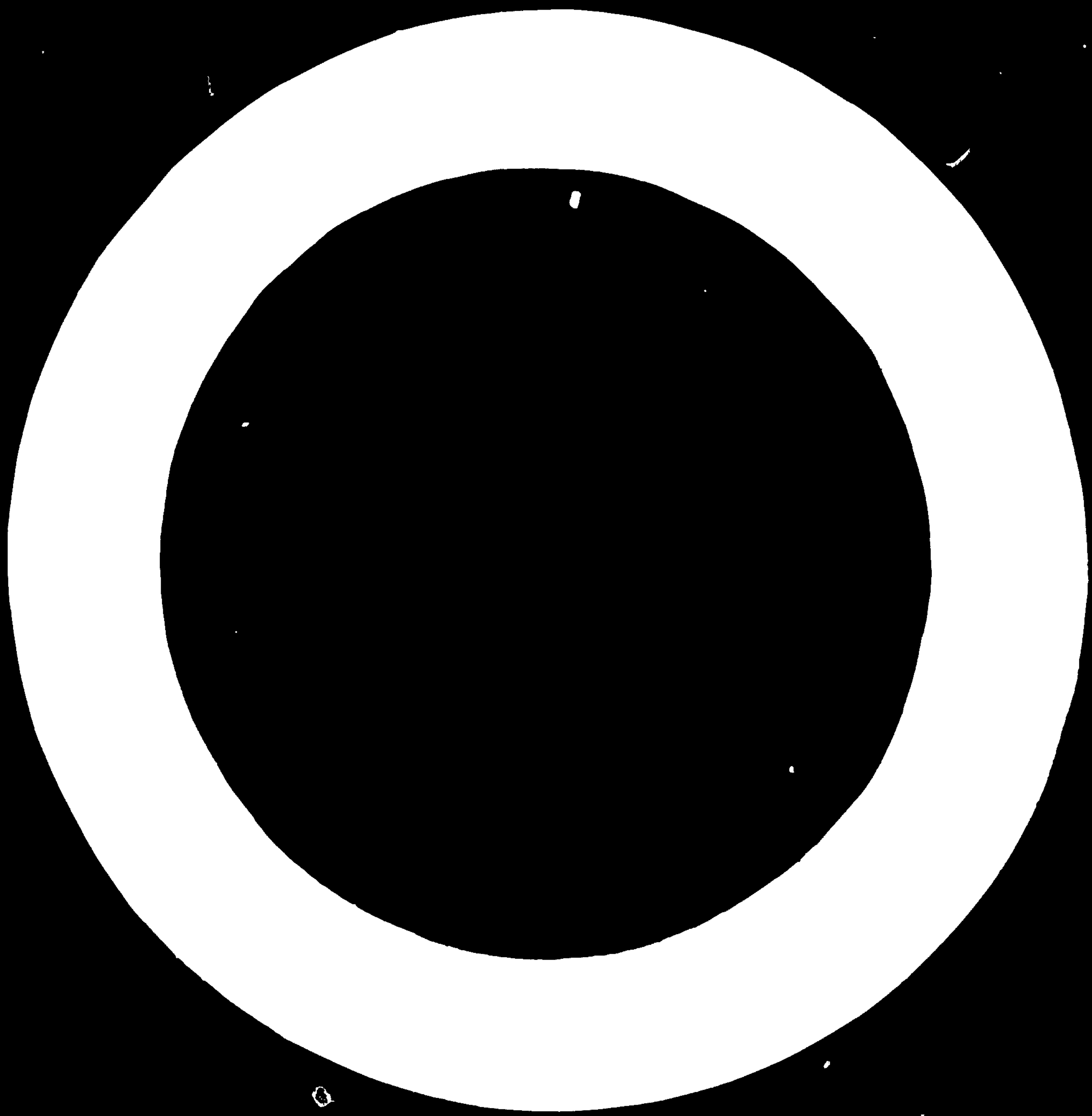

Pressure [illegible] pre[illegible] vacuum [illegible] penetration.

Diffusion [illegible] only [illegible] exchange with the sap [illegible]

Plants [illegible] per charge; each [illegible] boiler operator [illegible] information on technical specifications, [illegible] maintenance [illegible]

The complexities of the above process [illegible] avoided by using pressure treatment without heat - since pressure pumps are generally less complicated than steam boiling equipment. Plants vary in size from 1m. to [illegible]m. in diameter, have capacities of [illegible] - 200m [illegible] per charge (which normally take about [illegible] hours) and lend themselves to mobile designs.

Solvent extraction methods are relatively new and are useful for refractory timbers but require sophisticated equipment and a higher degree of operating and maintenance skills.

Vacuum treatment uses a pressure differential of about 1kg./cm.[illegible], usually with pentachlorophenol, and is useful for joinery work where the wood must be left dry and ready for use.

The hot and cold non-pressure method uses oil-based preservatives (such as creosote) and is relatively safe and easy to use. Tunnel sprayers are effective for large scale prophylactic treatment of sleepers. The equipment is simple and operating/maintenance skills are elementary.

Quality control involves primarily tests for retention and depth of penetration, but must be incorporated in the plant [illegible].

Finally, the three main types of preservatives are described; they are oil-based (creosote), water-borne (copper-chrome-arsenic compositions) and solvent-based (pentachlorophenol). Creosote is very widely used, has good anti-leaching characteristics, but it has an unpleasant smell and is a fire hazard immediately after treating. Water-borne preservatives protect against a wide variety of insects and bio-degrading agents, and are used in cooling towers, sleepers, poles, marine and mining works and particularly for construction timber, since they are clean and odourless and surfaces can be polished or painted right after treatment. Solvent-based preservatives are clean and effective, but require a fairly sophisticated organic industry to produce the pentachlorophenol.

Organisation des Nations Unies pour le développement industriel

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

Vienne, 19-23 novembre 1973

CHOIX DE L'EQUIPEMENT ET DES PRODUITS UTILISES POUR LA PRESERVATION DU BOIS[1]

par
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Le document traite des divers procédés, ainsi que du matériel et des produits utilisés aujourd'hui pour la préservation du bois et analyse les avantages et les inconvénients de chacun d'entre eux, afin d'aider les industriels des pays en voie de développement à choisir les solutions qui leur permettront de résoudre au mieux ce problème.

Les quatre procédés décrits sont les suivants : traitement sous pression, sous vide, sans pression et par diffusion. Dans certains cas, il est nécessaire de faire subir au bois un traitement préalable et un conditionnement (séchage par diverses méthodes, chauffage à la vapeur et mise sous vide et ébouillantage sous vide). Mais avant de traiter le bois, il importe de lui faire subir le maximum d'usinage.

Les procédés sous pression permettent de bien contrôler la préservation, encore que le procédé à chaud et à froid sans pression soit presque aussi efficace et présente pratiquement les mêmes avantages. La créosote convient particulièrement bien à cette méthode. Le badigeonnage, le trempage et la pulvérisation conviennent mieux pour une protection temporaire ou limitée.

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[1] Les opinions exprimées dans le present document sont celles de l'auteur et ne reflètent pas nécessairement les vues du Secrétariat de l'ONUDI.

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Dans les traitements sous pression (procédé à cellules pleines, procédé à cellules vides et procédé Rüping), le bois est traité alternativement sous vide et sous pression. Ces procédés permettent, en général, d'obtenir des taux élevés de rétention et de pénétration.

Les procédés par diffusion s'appliquent au bois fraîchement coupé, ils comportent des échanges d'ions avec la sève (méthode de montée de la sève) à basse pression (procédé Boucherie).

Les autoclaves utilisés pour le traitement thermique sous pression peuvent recevoir des charges de 30 m^3 à 150 m^3, le traitement d'une charge dure environ quatre heures mais il faut un chauffeur qualifié et un contrôle rigoureux. L'auteur donne d'autres renseignements concernant les spécifications techniques du materiel, la main-d'oeuvre et l'entretien.

Le traitement à froid sous pression permet d'éliminer les inconvénients du procédé précédent, en effet les compresseurs sont généralement moins complexes que les autoclaves. Les cuves de compression qui peuvent être mobiles ont un diamètre allant de 1 m à 2,50 m et leur capacité permet de traiter en quatre heures environ des charges de 150 m^3 à 200 m^3.

Les méthodes par extraction des solvants sont relativement nouvelles, elles sont utiles pour les bois réfractaires, mais elles nécessitent un équipement perfectionné dont l'exploitation et l'entretien demandent une main-d'oeuvre très qualifiée.

Dans le traitement sous vide, le bois est soumis à des différences de pression de l'ordre de 1 kg/cm^2 et traité généralement au moyen de pentachlorophénol; ce traitement est utilisé géneralement pour les bois de menuiserie qui doivent rester secs et pouvoir être utilisés immédiatement.

Pour les méthodes à chaud et à froid sans pression, d'un emploi relativement facile et sûr, on utilise des préservatifs à l'huile, comme la créosote. Les tunnels de pulvérisation sont indiqués pour le traitement prophylactique en grandes séries des traverses de chemins de fer. L'équipement est simple et son exploitation et son entretien ne demandent qu'un minimum de qualifications.

Le contrôle de la qualité comporte essentiellement des tests de rétention et de pénétration, qui doivent se faire au moyen d'instruments incorporés dans les cuves de traitement.

Enfin, l'auteur décrit les trois types principaux de préservatifs : les préservatifs à huile (créosote), en solution aqueuse (composition cuivre-chrome-arsenic) et à base de solvants (pentachlorophénol). L'emploi de la créosote est très répandu car ce produit a un bon pouvoir d'imperméabilisation, mais il dégage une odeur désagréable et rend le bois très inflammable immédiatement après le traitement. Les préservatifs en solution aqueuse protègent le bois contre une grande variété d'insectes et d'agents biodégradants, ils sont utilisés pour les tours de réfrigération, les traverses de chemins de fer, les poteaux, les bois utilisés pour les ouvrages marins et les bois de mine et surtout les bois de construction, car ils sont propres et sans odeur et ils permettent de polir ou de peindre le bois immédiatement après le traitement. Les préservatifs à base de solvants sont propres et efficaces, mais la production de pentachlorophénol nécessite une industrie chimique bien développée.

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CONTENTS

INTRODUCTION

The need for protection of timber against insect or organic attack is perhaps more urgent in developing countries than in developed ones. Timber is still a major constructional material in developing countries and is still the most economic of all building materials when compared to steel, concrete, plastics, etc., which may have to be imported. Many developing countries have found, to their dismay, that their once abundant forest wealth has been depleted to such an extent that, without rational utilization of the available timber, they will not be able to meet future timber requirements. It is a sad commentary on the situation that more timber is used to replace insect and organic attacked timber than for fresh uses. Proper preservation of timber can go a long way in changing this state of affairs.

This paper outlines the different types of processes, equipment and preservatives available today and considers the pros and cons of each so that the best combination suitable to a particular developing country, as far as availability of raw materials, suitability of manufacture, labour skills, etc. are concerned, can be selected.

I TYPES OF PROCESSES AVAILABLE

There are four types of processes for wood preservation:

- Pressure process
- Vacuum process
- Non-pressure process
- Diffusion process

Pressure processes can be divided into three sub-processes:

- With heat
- Without heat
- With solvent recovery

Vacuum processes are generally based on a double-vacuum process principle.

Non-pressure processes comprise:

- Hot and cold
- Dipping
- Brushing
- Spraying

Diffusion processes consist of:

- Ascent of Sap method
- Boucherie process

It is essential, whatever the method adopted for preservation, that pre-treatment and conditioning routines of one sort or another should be given before the timber can be treated effectively.

6. Pre-treatment and Conditioning

Timber must be prepared for treatment; there are two types of routines that are necessary to follow before timber is treated:

1. All the final carpentry work, such as adzing, pre-drilling, etc., should be completed in order to bring the timber as close as possible to its final physical dimensions, thus avoiding any further work on the timber after treatment has been carried out. For instance, for sleepers it is necessary to cut them to final sizes; for poles it is necessary to cut them to final sizes as well as to taper the small end to prevent rain water from collecting, and drill the holes for the bolts holding the cross-arms. Similarly, in construction timbers - say for door and window frames - final dimensions should be obtained as far as possible. In practice, a certain amount of carpentry work has to be done on site for accurate fitting but this should be cut down as much as possible.

2. Conditioning of timber is necessary to bring down the moisture content to a point where timber will readily accept treatment; timber with free water will not accept as much preservative as timber without free water. Therefore, the timber has to be dried to the fibre saturation point, between 25% and 30% when all the free water has been lost. Methods of conditioning are:

- Air seasoning
- Pre-drying
- Kiln drying
- Steaming and vacuuming
- Boiling under vacuum

a.) Air drying is almost the universal way of removing moisture from the timber. In practice, the timber is open-stacked so that free air will circulate through the stack. The timber should be under a roof, but all the sides of the shed or building should be open and free of obstruction for air movement. Air drying is time consuming and entails large inventories of timber. It would take a minimum of at least a month in an atmosphere which is not very humid to bring down the moisture content in the timber to an acceptable level for treatment.

b.) Pre-drying consists of blowing air through the timber stack which has been spaced in layers so that all the surfaces of timber are free to air movement. In practice, a pre-drier consists of fans of 1-2 metres in diameter which blow air through the stack just as in a regular seasoning kiln. Air is passed only once, with fresh air continually being sucked in by the fans. This system, which does not use heat (or may use small amounts of heat by means of a steam-heated coil), reduces the moisture content faster than be air seasoning and, at the same time, does not produce damage to timber since moisture content is brought down gradually. Such pre-drying results in savings of time and hence of inventories and also makes space in regular drying kilns for timbers whose moisture content has to be brought down to, say, 12% to 14%, for other uses such as in joinery construction.

c.) Regular kiln drying can also be done to bring down the moisture content of timber to a point where it is suitable for treatment. The disadvantage here is that an expensive piece of machinery is used for doing a job that can be done more easily by either efficient air drying or pre-drying.

d) Steaming and vacuuming in the pressure cylinder of a regular treatment plant are especially suitable for sleepers and poles which usually take a long time to dry down to 25% to 30%. Such items are difficult to dry in a short time by either air drying or even by pre-driers, and would be uneconomical to season in a regular drying kiln. In the steaming and vacuuming process the sleepers or poles are introduced in the pressure cylinder of the treatment plant and are then subjected to about 1/3 kg./cm.2 steam pressure for 6-7 hours, by which time the temperature of the sleeper or pole down to the core is almost at the temperature of the steam, i.e. 100°C. At this stage the steam is released into the atmosphere and a fairly good vacuum is drawn. This results in flash steam formation due to the reduced pressure and a very large quantity of moisture from the sleepers or poles is removed in a very short time. With this method, it is possible to bring down moisture from fresh sawn sleepers or freshly cut poles from green to about 25% in approximately 2 days time, rendering them suitable for pressure treatment in the same cylinder. This system of course requires a regular pressure treatment plant.

e) Boiling under vacuum is suited to creosote treatment of sleepers and poles. In this method the cylinder is loaded with the sleepers or poles and is then flooded with hot creosote. It is then heated up by creosote continuously until it is almost at the same temperature as the creosote, up to the core. The working temperature of the creosote is usually between 90°-95°C. While it is being heated, a vacuum is drawn over the liquid; this again results in the formation of the flash steam which is continually withdrawn through a goose neck which is more than 10 meters long and results in the creosote vapours recondensing back to the pressure cylinder and the water vapours condensing on the downward of the goose neck and collecting in a condensate collector. By measuring quantity of water collected and calculating it against the known volume of the sleepers or poles, it is possible to know when sufficient moisture has been removed so as to make the timber suitable for preservative treatment. This system also entails the use of a regular pressure treatment plant and can be applied only in the case of creosote treatment.

B. Non-pressure Processes

Non-pressure processes usually comprise of:

- Hot and cold
- Brushing
- Dipping
- Spraying

1. The hot and cold process is, perhaps, most preferable of the non-pressure processes. It may be remembered that the criterion of the wood treatment comprises putting a known quantity of preservative into a unit volume, to a definite depth of penetration. In the case of pressure processes the amount of control in the operator's hands is far greater than in the case of non-pressure processes where the operator has control over only one of the parameters controlling retention and penetration. The hot and cold process is perhaps the closest that can come to pressure treatment, not only from the point of view of some control, but also from the point of view of being able to impregnate the largest quantity of preservative to the maximum depth possible among non-pressure processes.

The hot and cold process is particularly suitable for oil-type preservatives that can be applied at temperatures of 90 [illegible] C, such as creosote. In this process the timber to be treated after proper pre-treatment and conditioning is loaded in a mild steel tank which can be heated. The timber is then weighed down and the tank filled with creosote. The creosote is then boiled for a suitable length of time (3-4 hours) to enable the timber to come up to a temperature of about the same, down to the core. The heat source is then removed and the timber allowed to cool along with the preservative to ambient temperatures. During the heating process, air that is trapped inside the timber is expelled and when the heat source is removed the preservative rushes in to fill the space left vacant.

2. <u>Brushing</u>, <u>dipping</u> and <u>spraying</u> are all surface type treatments which are best adopted for prophylactic treatment of untreated timber likely to be sent for regular preservative treatment at a later date. This applies particularly to sleepers and poles which are usually extracted (and sawn as necessary) and stored at jungle depots for considerable periods of time before they are transported to a central treatment yard.

Spraying is perhaps the easiest way of large scale prophylactic treatment and several types of knapsack sprayers are available which can do the job without difficulty. For some light surface applications such as for cable drums, furniture timber, etc., dipping is a suitable alternative, provided the incidence of insect or organic attack is low. The timber should preferably be quite dry say about [illegible] moisture content, and it should be steeped for at least an hour so that some absorption of the preservative occurs.

A good method of large scale spraying without any waste of preservative is by the use of a tunnel sprayer. In this, a long conveyor passes through a tunnel in which several sprays are directed peripherally at the timber being carried on the conveyor. As the sprays are located all around the timber, complete drenching of timber is possible and large quantities can be treated in this way, while recovering the drip fully to be used over again. A small pump is sufficient to maintain the necessary spray system in the tunnel.

C. <u>Pressure Processes</u>

The main pressure processes are:

- Full cell
- Empty cell (also called Lowry)

A third pressure process is the Rueping process, which is also discussed here.

1. In the <u>full cell process</u> timber is subjected to a vacuum in the pressure cylinder initially, of the order of 450mm.-600mm., so as to extract as much air as possible which has been entrapped in the timber. While holding the vacuum, the cylinder is flooded with preservative and immediately thereafter the necessary working hydraulic pressure is created - usually 10-14 kg./cm.2. After the pressure cycle, which lasts anywhere from half an hour to two hours, is over, the preservative is drained off and a final vacuum is applied to remove the surface drip. The full cell process is ideal for moderately refractory timbers, which are resistent to treatment and will not easily take the required retention of preservative per unit volume or give the necessary depth of penetration. Such treatment is also given where high retentions are required for poles, sleepers, marine timber, cooling tower timber and for piling timber.

3. The Lowry process does not utilise an initial vacuum; however, the rest of the process is the same as that of full cell. At the end of the pressure cycle, when the pressure is released, air inside the timber which is compressed to a certain extent due to the introduction of preservative under pressure "kicks back" some of the preservative out. This process is used mainly for non-refractory timbers where, if the full cell process were used, the retentions per unit volume would be more than specified. The "kick back" ensures that part of the preservative is returned to the pressure cylinder while at the same time maintaining a good depth of penetration.

4. In the Rueping process an initial pneumatic pressure is given after timber is loaded in the pressure cylinder, and the rest of the pressure cycle and final vacuum cycle are the same as for the full cell process. Due to the initial impregnation of air, usually at about 5 kg./ cm.2, the "kick back" after release of pressure is far greater than that of the Lowry process, ensuring that more preservative is removed from the timber when the pressure cycle is completed. This cycle is particularly suited to non-refractory species of timber where low retentions are required without any decrease in the depth of penetration. It may be relevant to here point out that irrespective of the process used, a good depth of penetration is one of the criteria for good pressure treatment.

D. Diffusion Process

The diffusion process has been specified separately, since quite good results can be obtained from this process if proper care is taken. There are two such processes:

- Ascent of sap method
- Boucherie process

1. While the principle of both processes is the same, the ascent of sap method is generally suitable for fence poles and short length poles where fence posts which are freshly felled are debarked and put into a 40 gallon barrel immediately. The barrel is then filled with a water-borne preservative solution. Due to the fluid sap, an ionic exchange takes place because of the differing concentrations between the sap and the water-borne preservative solution, which results in the preservative entering into the timber and the sap being displaced. After a few days the fence posts are removed and turned over and again put into the solution for a few days. Generally it is possible to obtain good retentions and penetration with this method, provided the timber is absolutely fresh. The timber is then removed and packed in alkathene paper and kept for about 15 days for the diffusion process to be completed.

2. The boucherie process is still adopted for bamboos and for poles, and entails a certain amount of equipment. In this process a pressurized container holding water-borne preservative solution feeds the solution at a pressure of about 1/3 kg./ cm.2 to poles or bamboos which are kept slightly upended. The final fluid connection is made by means of a motor tube or cycle tube, so that no preservative will leak. Here again a displacement of sap takes place both because of diffusion and the pressure exerted in the pressurized container. Such pressures can be created simply by means of an air pump. This process has been adopted quite successfully for treating a large number of poles and bamboos in the forest. Here again, it is essential that the poles or bamboos are absolutely freshly felled; otherwise the process would not work.

II TYPES OF PRESSURE TREATING EQUIPMENT AVAILABLE

The pressure processes available are:

- With heat:
  Creosote treatment for sleepers and poles
- Without heat:
  Water-borne preservative treatment for sleepers, poles, cooling tower timber and constructional timbers
- Solvent extraction pressure process for sleepers and poles
- Vacuum pressure processes for constructional timbers

A. Pressure Treatment with Heat

Oil-based preservatives like creosote require application of heat in order to make them sufficiently non-viscous for impregnation. A typical creosote treatment plant consists of a pressure cylinder along with service and storage tanks, all of them fitted for heating - generally by steam coils. Such units require, of course, a boiler to produce the required quantity of steam. Most creosote plants now in use in the world are usually equipped for treatment of sleepers and poles. Size of such plants vary from a capacity of 30 cu.m. to about 150 cu.m. per charge; each charge would take approximately 4 hours. These plants can also be fitted with accessories for steaming and vacuuming or for boiling under vacuum, so that the same plant can do both the conditioning, i.e. removal of moisture, as well as pressure treatment of sleepers or poles.

Creosote pressure treatment plants require manufacturing facilities comprising plate bending machines, electric welding sets, general smithy shops for the manufacture of dished ends and machining facilities for flanges and other components of the door comprising lathes which can take flanges of at least 2 meters in diameter.

Raw material requirements are mainly steel plates, not necessarily of boiler quality but preferably tested mild steel plates conforming to international specifications with a working tensile stress of about 3 tonnes per cm^2. The ancillaries required for the treatment plant of this type would be comprised of steam or electrically operated pressure pumps and, of course, a boiler which would be fabricated so as to come under the Boiler Act. Black pipes of up to 6" in diameter, along with gun-metal or cast steel diaphragm-type valves suitable for working pressures of up to 14 kg./cm2, are also necessary for the plant.

Labour required would be:

- a competent certified boiler operator
- a plant manager who could make calculations for retentions per volume of poles and with knowledge of operating valves, starting of vacuum/pressure pumps and their general maintenance.

Casual labour for loading and unloading poles need not necessarily have experience, since it can be picked up at the time of operation.

The maintenance of creosote plants entails periodic checking of the prime movers, boiler, replacement of packing for the door of the cylinder and the valves and general lubrication for moving parts. From the point of view of safety, the use of hot creosote in the pressure cylinder at a working pressure of 10-14 kg./cm.2, as well as the use of steam at pressures of 5-6 kg./cm.2, entails a certain amount of risk in that if the units are not properly maintained there is danger, for example, of hot creosote escaping from a broken pipe or valve.

Specifically, this requires good maintenance of both the boiler and the various valves and packings on the pressure cylinder.

There is some air pollution, especially when the door of the pressure cylinder is open and a certain quantity of fumes escapes, but creosote itself is not considered harmful to health. However, since creosote treatment produces an extremely large amount of sludge, frequent cleaning of the pressure cylinder for the removal of the sludge, and its safe disposal, is one of the points that must be taken into consideration.

B. Pressure Treatment without Heat

This usually refers to pressure treatment plants working at ambient temperatures mostly using water-borne preservatives or solvent-based preservatives. One of the advantages of this type of treatment, which can not only be used for sleepers or poles but also for constructional and other materials, is that the boiler and its complexities are removed.

The plant consists essentially of a pressure treatment cylinder, storage tank, mixing tank, vacuum pump, pressure pump, pipelines and valves. Plant sizes vary from 1 meter to 2½ meters in diameter so that treatment capacities of the order of 150 - 200 cu.m. per charge are available. Since heating is not required, cycles can also be reduced to obtain a charge in approximately 4 hours time. This type of plant readily lends itself to mobile designs which are especially useful in taking the plant to the timber rather than timber to the plant. For developing countries, where centralization of treatment facilities may be a problem, mobile plants have proved to be useful, since they have been able to travel to small depots where timber is kept and treated. Such plants can be towed by jeep, tractor or even drawn by animals from place to place. They can also be completely self-sufficient because they can be operated with an air-cooled diesel engine which is mounted on the plant itself. Manufacture of such plants entails similar facilities to those described under creosote plants (Section II A) but since neither the boiler nor steam coils are required, complexity is reduced.

Raw material requirements are also similar to those of creosote plants but, since no boiler is required, boiler plates are not necessary. Operating skills are slightly less demanding, as the plant operator need not have any basic knowledge of boiler or steam-lines under pressure. He must have a general knowledge of calculation of volumes, retentions, etc. Less maintenance is required than for creosote plants. The safety factor is quite high due to the nature of operation in the cold, and even if there is a constant leakage it is not necessarily dangerous because it is only a solution at normal temperature.

There is absolutely no atmospheric pollution with water-borne preservatives. There is some sludge formation in the storage tank as well as in the sump under the pressure cylinder door which is caused mainly by the reaction of the preservative on the sappy matter discharged from timber. Such sludge can be de-activated to prevent the harmful elements of the individual chemicals from contaminating water supplies, etc. However, generally there are fewer sludge problems with water-borne preservative treatment than with creosote treatment.

C. Solvent Extraction Methods

This pressure process is a relatively new development and has found some favour in the treatment of highly refractory timbers such as Douglas Fir, which could not be satisfactorily treated before this method was evolved. The process, which is called "Cellon" in the U.S.A. and "Drylon" in the U.K., uses the full cell process to impregnate preservatives like Tri-butyl-tin-oxide, the carrying medium being liquified petroleum gas (L.P.G.). Due to the very high creep characteristics of L.P.G. into timber, it is possible to carry T.B.T.O. deep into the core of the refractory timber. After treatment is over and pressure is released, the L.P.G. vapourizes and is extracted from the pressure cylinder re-compressed and condensed back to liquid.

Such plants are necessarily sophisticated and safety features are of paramount consideration, in view of the L.P.G. The basic plant is the same as that of a pressure treatment plant, but additional items include a high pressure storage tank for L.P.G., plus necessary sealed compressors for compressing gas to liquid, as well as a wide range of safety devices to detect the slightest leakage of L.P.G., etc. The basic manufacturing technologies are about the same as those required for pressure treatment plants. The large quantity of automatic instruments ensures gas leakage prevention and detection.

Operating skills required are of a high order due to the fire and explosion hazards and require at least one man specially trained on such plants. The plant operator must at least be a qualified engineer capable not only of following safety regulations but also of maintaining complete automatic instruments and sensors.

Also of a high order is the type of maintenance required. Pollution is not a problem; there is very little sludge especially with TBTO, though it is reported that with pentachlorophenol there were problems of sludge formation.

D. Vacuum Treatment

This treatment consists of using atmosphere pressure for the pressure cycle, i.e. an initial vacuum is drawn in the cylinder. After flooding the cylinder with preservative solution, the vacuum is released so that a differential pressure of about 1 kg./cm.2 is available for pressure impregnation.

Vacuum treatment has found wide acceptance is what is now known as double vacuum treatment - an initial vacuum followed by a final vacuum to remove excess drip, using solvent type preservatives like penta-chlorophenol. It has been found especially useful in the treatment of joinery items where necessary retentions have been easily obtained while at the same time leaving timber completely dry and ready for use. Such treatment is not suitable for heavy retentions such as for poles and sleepers.

The basic manufacturing requirements are the same as those for any other pressure plants.

Raw materials and operating skills are also the same as those for any other pressure plants. Such plants are considered very safe to use since they are on a negative cycle rather than a positive one. There is very little pollution.

III TYPES OF NON-PRESSURE TREATING EQUIPMENT AVAILABLE

A. Hot and Cold Method

This method is perhaps the next best to pressure treatment, especially for sleepers. However, it can only be used for oil-based preservatives such as creosote on account of the heat involved, which rules out water-borne preservatives.

The hot and cold tank can be made to any size, depending upon the requirements, and is usually made from mild steel. It must have a device to weigh sleepers down; this could be heavy stones which are placed on top of the sleepers. Heating arrangements can be as follows: a fire could be built under the tank utilizing wood chips and waste, or, if a boiler is available, a steam heating coil which is protected so that the sleepers will not damage it could be placed at the bottom of the tank. Manufacture of this sort of equipment is relatively simple but requires raw materials like mild steel plate and welding facilities.

Operating skills are not necessary, provided labour can get some practice in loading/unloading sleepers, which can perhaps be done by means of a chain and pulley block and a hoist operated from an overhead beam.

Maintenance required is virtually nil. There is some degree of atmospheric pollution caused by the fumes of creosote, but there are no severe safety problems connected with this method.

B. Tunnel Sprayers

Basically a tunnel sprayer is ideal for large-scale prophylactic spraying of sleepers, which are run on a roller-type conveyor either manually or electrically operated. The timber enters through a tunnel in which nozzles placed along the periphery of the tunnel spray the preservative solution at the timber, thereby ensuring that all the timber is properly sprayed. The tunnel sprayer can be made to any size depending on the capacity required. If they are manually operated, it is better to have a large number of tunnel sprayers rather than one large one. A pump operated by a diesel engine or electric motor is necessary for pumping the solution to the nozzles.

The tunnel sprayer is an economical unit in that virtually no solution is lost by drip. After the timber emerges from the rear end of the tunnel, the drip is caught by means of a sloping trough which extends for perhaps 3-4 meters beyond the rear end of the tunnel.

Manufacturing facilities are simple; they require mild steel plate and sheet, electric welding facilities, pipes, valves, electric motor or diesel engine, centrifugal pumps, brass nozzle, etc. Operating skills are elementary: the plant operator should have some knowledge of maintenance of pumps, diesel engines or electric motors and occasional mechanic repair of the rollers.

Maintenance usually consists of applying grease to the roller's bearings. Safety hazards and pollution are minimal. Most tunnel sprayers use water-borne preservative solution.

C. Dip Treatment

Dip treatment is simple and requires a mild steel tank or even a wooden vat. It is preferable to have a hoisting arrangement in the form of a chain pulley block and hoist operating from a beam.

D. Spraying

Spraying is one way of prophylactic treatment, especially at large depots where untreated sleepers and poles are stacked. Knapsack sprayers of simple design utilizing a brass or copper pressurized container in which air pressure is built up by means of a hand operated air pump and flexible hoses connected to the brass nozzles are all the equipment consists of. More sophisticated designs utilize a small petrol engine and the whole unit is mounted on a trolley which can be trundled between sleeper or pole stacks with two or more nozzles operated by men.

No special operating skills are required, except maintenance of engines and cleaning nozzles, as well as occasionally overhauling air pumps, etc. Very few safety precautions are required. Pollution is minimal.

IV TESTING AND QUALITY CONTROL EQUIPMENT FOR WOOD PROCESSING

A. Quality Control

Adherence to specifications for retention and depth of penetration are the main considerations in quality control of wood preservation. Quality must be built-in in the plant itself. Testing after treatment only serves to double-check whether the treatment is alright. However, if the treatment is found not to be alright the timber has to be re-treated all over again. Maximum control is only possible with pressure systems such as the full cell, Lowry or Rueping processes, where, after a few trial and error charges, it is possible to select the strength of solution, working initial vacuum, pressure, final vacuum and the various timings for each part of the process. In the case of creosote treatment control over temperature is also essential.

In any modern treatment plant, say for water-borne preservatives, storage tanks have sight gauges calibrated in gallons or litres so that initial and final levels of the solution can be read off in order to arrive at the quantity of solution absorbed by the timber. From the log sheet it is possible to find out the quantity of timber in terms of volume and thus arrive at the final retention per cubic volume. Another way is to have weigh bridges to measure the timber and then calculate the volume of timber based on weight to arrive at the final retention per unit volume.

Testing of depth of penetration can be undertaken at the plant itself by such instruments as increment borers, which can remove a sliver of the treated timber through the cross-section and which is then sprayed with suitable re-agents which change the colour in the presence of the preservative, to identify the depth of penetration.

For water-borne preservative treatment, for example, the strength of the treating solution can be easily measured by a hydrometer at the plant itself. Normally the testing of preservatives supplied by manufacturers need not be carried out, since most manufacturers of wood preservatives have their own quality control systems. However, it is usual for any plant to have a testing station or laboratory, which is described below in Section IV B.

B. Testing of Wood Preservatives and Treated Timber

For creosote the main tests are in connection with discovering the quantity of creosote content, which establishes its effectiveness. In the case of treated timber, the quantity of creosote is measured after timber samples are digested and the creosote extracted from it.

For water-borne preservatives like Copper-Chrome-Arsenic compositions, individual chemicals, such as Arsenic Pentoxide, Copper Sulphate and Sodium/Potassium Bichromate, can be tested by suitable chemical analysis which will reduce the individual chemicals so as to obtain the weight of the actual metals, namely Arsenic, Copper and Sodium, from which it is possible to find out whether the ratios of the chemicals mixed are correct.

In treated timber, the timber samples are digested and individual chemicals are extracted from it and again analysed to find out the quantities present.

V TYPES OF PRESERVATIVES AVAILABLE

Broadly speaking, there are three types of preservatives, with a whole range of others in between. The main considerations in the use of a particular preservative are availability, efficacy based on end-use, type of process to be used, safety precautions and pollution.

The three broad ranges of preservatives are:

- Oil-based: such as creosote
- Water-borne: such as Copper-Chrome-Arsenic compositions
- Solvent-based: such as Pentachlorophenol

A. Oil-based Preservatives

Creosote is a by-product of the coal-tar industry and is usually available in steel mills from their coking ovens. Coal-tar creosote is probably the most widely used today. By itself, creosote is an excellent preservative and has perhaps the longest history of use in the world. It has very good anti-leaching characteristics and has been used successfully mainly for treatment of sleepers and to some extent poles. Creosote treatment has to be done by pressure at least by the hot and cold process.

Creosote has an unpleasant smell and timber treated with it cannot be painted; hence it does not find acceptance for use where people or animals come into contact with it. It is also a serious fire hazard immediately after treatment, although its ignition properties gradually wear off if the timber is left by itself for a few weeks. There is a tendency for creosote to bleed from timber immediately after treatment.

Creosote treatment causes some air pollution due to fumes and it also creates sludge problems in the pressure cylinder, which must be cleaned periodically and the sludge disposed of. There are no health hazards to labour arising from its use, provided suitable precautions in the form of knee-high rubber boots and long rubber gloves are taken.

B. Water-borne Preservatives

The best example of a water-borne preservative is the Copper-Chrome-Arsenic composition, which is a wide spectrum preservative and is resistant to a large variety of insects and bio-degrading agencies; this includes termites, borers, marine organisms and many types of fungi.

The treatment plant requirements for C.C.A. compositions are much less complicated than those for creosote, since they do not require heat, thus enabling C.C.A. compositions to also be used for mobile plants. Such compositions have highly anti-leaching properties and so find use in the wooden fill for cooling towers, for example, where continual water drenching takes place for years on end. Creosote cannot be used for wooden fill in cooling towers because the turbines pick up the sludge caused by creosote and become damaged. The C.C.A. compositions can also be used for sleepers, poles, marine and mining timber and for constructional purposes. They are particularly suitable for constructional timbers on account of the clean and odourless surface of the timber so treated, which can also be polished or painted.

There are no particular fire hazards caused by treatment with C.C.A. oompositions and they are not dangerous to health provided basic precautions are taken; workers must wear gloves and rubber boots and take care to wash their hands before they eat. It is a generally accepted fact that there is no special problem connected with the use of Arsenic, provided these basic precautions are taken. It would also be fair to point out that there has not been a single case of Arsenic poisoning from the preservative itself or from the treated timber since C.C.A. compositions have started being used. Very little pollution is caused by C.C.A. compositions and there are few safety hazards since treatment is done at ambient temperatures. The C.C.A. compositions cannot be used for the hot and cold process; they should either be used for pressure treatment or for brushing, spraying and dipping. Some degree of success has also been achieved with the double-vacuum process, although not as clearly defined as with the solvent-based preservatives such as Pentachlorophenol.

Raw materials for C.C.A. compositions are items such as Arsenic Pentoxide, Copper Sulphate and Sodium/Potassium Bichromate. It is doubtful whether many countries will have Arsenic Pentoxide, but this forms only one-eighth of the weight of the dry preservative and thus perhaps can be imported. For the other materials required, for example Copper Sulphate - Copper Ores and Sodium/Potassium Dichromatechrome Ores, may be available in the country in which case Copper Sulphate and Sodium/Potassium Dichromate can be made.

C. Solvent-based Preservatives

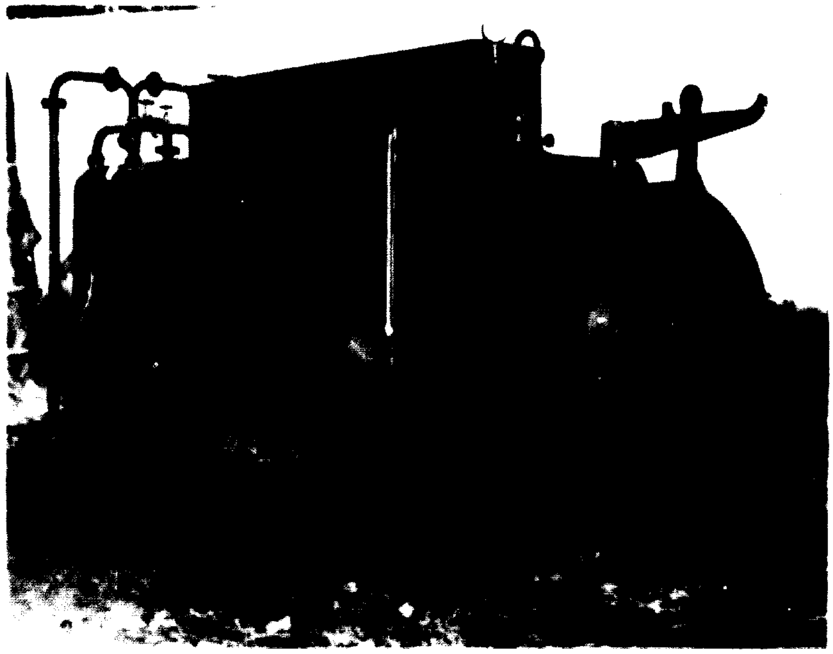
Pentachlorophenol may be described as a preservative which is most generally used by dissolving in kerosene or white spirit, although it may also be dissolved in oil. It is an excellent preservative, is widely used and has high anti-leaching qualities. It is particularly suited to the double vacuum process, which is a simpler form of pressure treatment. It leaves a clean surface within 2 hours of treatment: Pentachlorophenol treated timber can be readily painted provided the solvent is kerosene or white spirit with certain other additives.

Pentachlorophenol is a by-product of the Phenolic industry and thus a fairly sophisticated organic industry must be in existence if it is intended to produce Pentachlorophenol in a country. It is harmful to the skin and care must be taken in handling the solution or preservative itself, by wearing suitable gloves and rubber boots. There are no special problems connected with air pollution and sludge formation. Some safety features must be incorporated in a double vacuum treatment plant due to the presence of the solvent. Such features could be in the form of rupture discs in the event of spontaneous combustion in the cylinder or storage tank. Good anti-static arrangements must be used to prevent the build-up of static electricity.

Pentachlorophenol has been successfully used for treatment of sleepers or poles, as well as for constructional timber. The trend is towards treatment of joinery timbers rather than for sleepers or poles, mostly by the double vacuum treatment process.

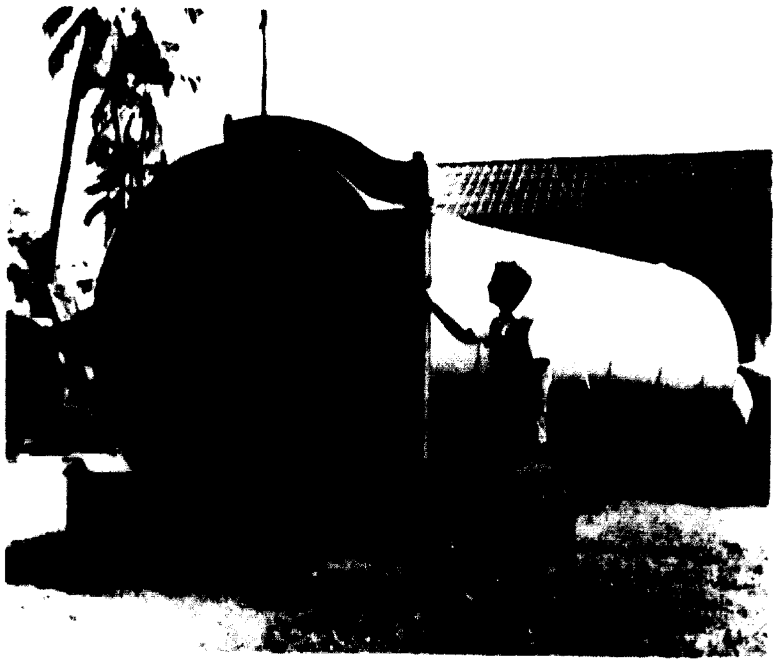
CONCLUSION

In conclusion, an attempt as been made in this paper to broadly outline the full range of treating equipment and preservatives, with their advantages and disadvantages. As much information as could conveniently be given on different aspects of manufacture, requirements of skilled labour, requirements of raw materials, safety considerations, pollution, etc. has also been discussed in order to present a clear picture of the technology of wood preservation. It is hoped that from these descriptions it will be possible for developing countries to select the best combinations possible, in line with their own specific requirements and limitations.



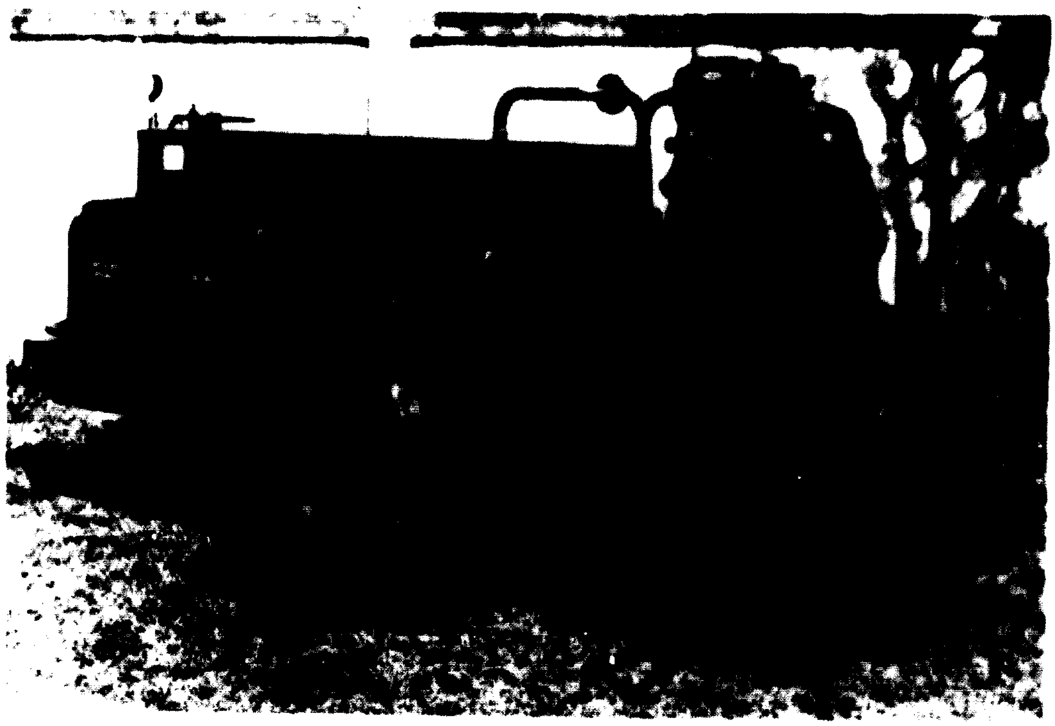
1. A semi-mobile plant using Copper-Chrome-Arsenic preservative. It has a capacity of about 2 cubic meters per charge. It can be run by an air-cooled diesel engine or electric motor.

2. A stationary treatment plant using C.C.A. preservative set up in the factory for a full test. It has a pressure cylinder of 1 meter in diameter and 6 meters in length.

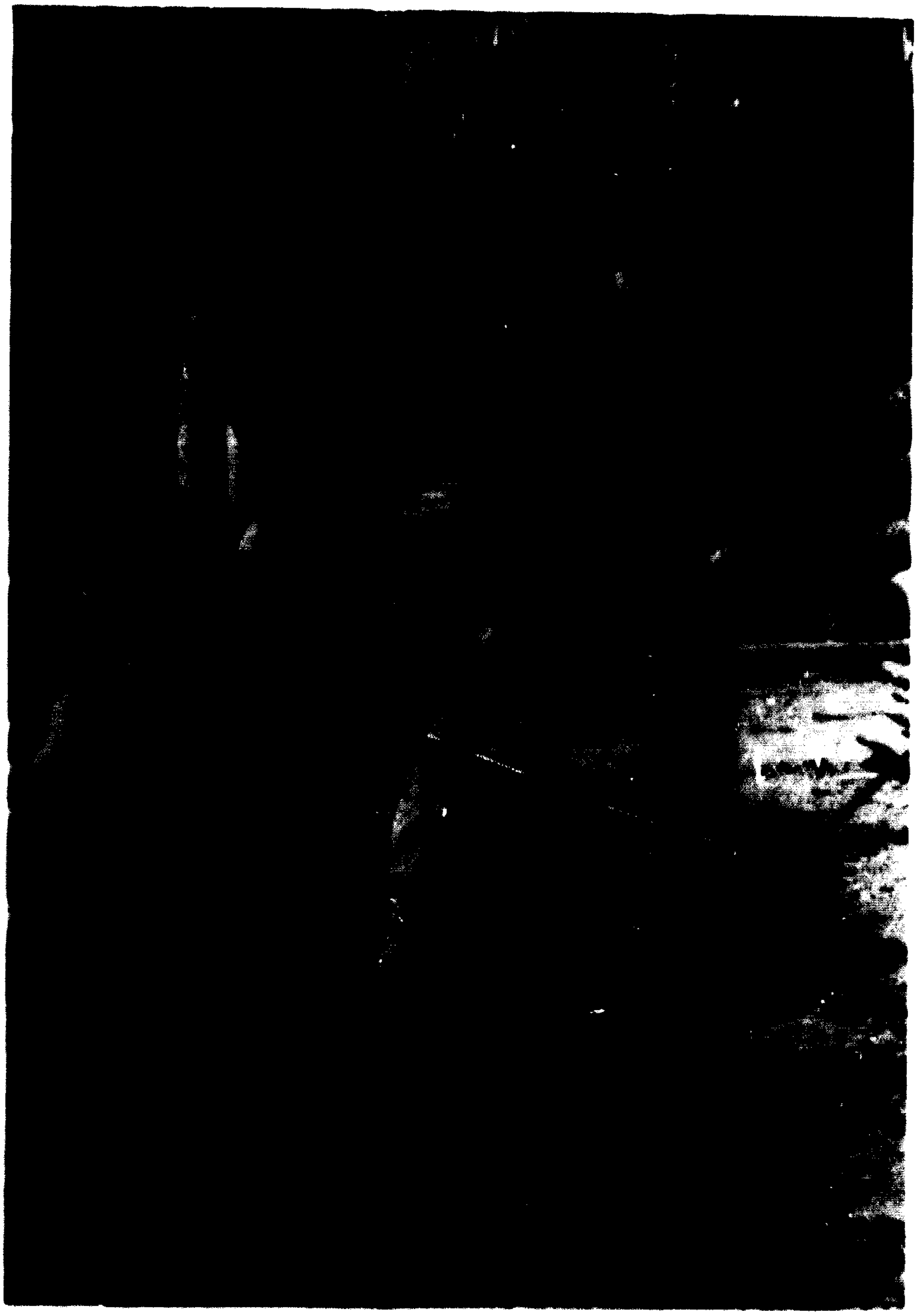


3. A pressure cylinder 2 meters in diameter and 8 meters in length. Note special design of Quick-lock door.

4. A complete stationary plant installation. Pressure cylinder is 1.25 meters in diameter and 13 meters in length. Capacity of treating is 5 cubic meters a charge.



5. A self-contained mobile plant. Can treat 1 cbm. a charge.
Note air-cooled diesel engine and wheel equipment.
Can be towed by jeep, tractor, or even by bull or camel.



6. Novel method of carrying poles for loading in trolleys of cylinder - a bullock-cart without the bullock!

7. Pole slung under cart being lowered onto trolleys.

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