

INSTITUUT VOOR TUINBOUWTECHNIEK — WAGENINGEN
Institute of Horticultural Engineering — Wageningen

STEAM STERILISATION OF SOIL WITH SIMPLE METHODS

by W.K.W. Broekhuizen and Ir. C.J. van der Post



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Preface

The mechanisation in agriculture and horticulture in the Netherlands has reached a level of high technology. This requires a high investment rate on the holdings. Very often it means that such advanced techniques cannot be used in developing countries.

The existing gap between the levels of development in the agricultural field demands special activities for the lower level. Therefore the Institute of Horticultural Engineering will pay also attention to the description of techniques applicable in countries with a low technical infrastructure.

A first subject is given in this publication. We hope that it will reach the people in the field of application.

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Introduction

In an extensive culture with a crop rotation and a normal weed growth there is an equilibrium between the soil organisms. This equilibrium can easily be disturbed in a monoculture with intensive soil cultivation and weed control. By using stable manure and if possible green manure one can stimulate the growth of the population of organisms. Nevertheless in a monoculture, soil born diseases occur more frequently. In particular to the soil used for propagating seedlings or young plants special attention has to be paid to its health. Good seed alone is not sufficient, especially for high valuable crops, also good plant material is required as foundation for a good crop. Therefore a regulate refreshing or sterilising of the soil of propagation beds can be recommanded.

Sterilising soil is possible with chemicals such as formaline, methylbromide and chlorpicrine. These methods are relative easy in application but restricted in possibilities of diseases control. A nearly allround and widely used method is steam sterilisation. This method will be discribed shortly in this paper with special attention to the construction and utilisation of simple apparatuses, applicable for steaming small quantities of soil to approximately one cubic meter. The manner of construction is chosen in such a way, that they can be manufactured locally with limited facilities. Other advantages are, the minimum of maintenance required and the simplicity of burning wood.

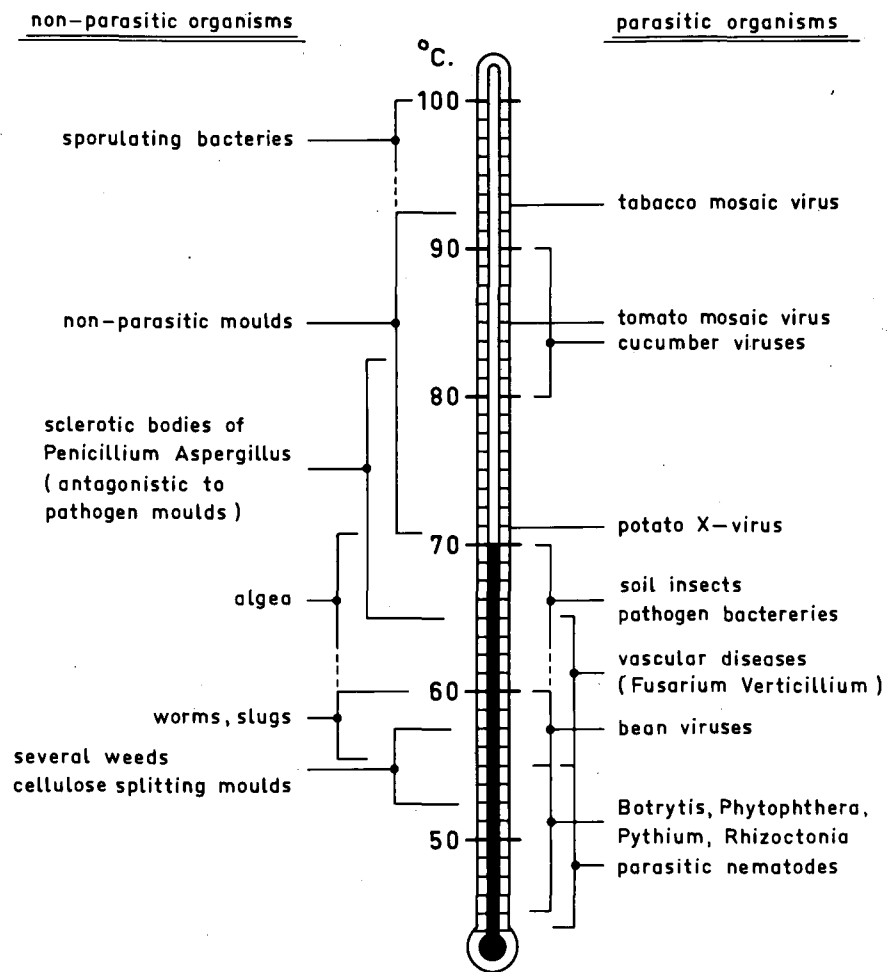


Fig.1 Killing temperature of some soil-born organisms after treatment of the soil for a period of 30 minutes.

The process of steam sterilisation

With steam sterilisation - heating of the soil to temperatures of 50 to 90° C (122 - 194° F) - the parasitic organisms (pathogens) of different kinds are killed. Warming up the soil with steam is very effective, because of the enormous transfer of heat with the condensation process: one kg of steam supplies 540 kcal at 100° C. As the heat capacity of a loose and normal moist soil is a 0,5 - 0,6 kcal per °C per dm³, roughly 50 till 60 kg of steam is required for heating one cubic meter of soil from 20 up to 70° C.

The regular distribution of the steam and the resulting heating of the soil requires a loose soil structure and a small overpressure (some dm's watercolumn) of steam. During the steaming process the water content of the soil increases somewhat by condensation of water. During the cooling period it is lost again partly by free evaporation. Also free drainage of condensed water must be guaranteed. To kill the relevant pathogens a temperature of at least 70° C has to be maintained evenly throughout the soil for half an hour or longer. All pathogens, such as fungi, bacteria and eelworms will then be killed, except some viruses (see fig. 1). On the other hand, long periods of steaming above 70° C induces many harmful chemical changes in the soil, and also the temperature raises far above that which is needed for the sterilization process.

Methods

The choice of method to be used strongly depends on the quantity of soil to be treated. For example: small quantities of propagation soil - a few hundred of litres approximately - can be steamed in sacks or in a container; for larger quantities - one or more cubic meters approximately - the steam may be blown into a heap of soil. Description of these methods follow.

Larger parts of ground, treated on the spot, can be steamed using perforated pipes that are dug into the soil or a perforated tube under a plastic sheet that covers the loose or cultivated soil. For this application bigger apertures for steam production are required than those described in this text.

Description of two simple sterilising units

Apparatus 1

Sterilising small quantities of soil is possible in a container placed directly above the steam producing water (fig.2).



Fig.2 Apparatus for steam sterilisation of soil placed directly above boiling water (inside view).

The soil is put into sacks placed on the wooden grate which lays over a container filled with water. The container is heated by a direct fire in the bottom compartment of the apparatus. The hot flue gases escape upwards through the side walls heating the whole container. Therefore, direct contact of the soil with the side wall must be prevented, as local overheating of the soil induces undesirable humus oxidation.

Small quantities of soil, up to 4 or 5 sachs of approximately 50 kg, heated in this way, can reach the desired temperature of 70⁰ C within approximately one hour.

It is necessary to control the amount of water in the basin throughout the steaming process. This can be done through a hole made in the lid of the container.

The whole apparatus is build up of welding sheet iron of 2 mm. To make a more efficient use of the fuel, the outer wall can be insulated by using a double iron sheet,

if available, filled up with rockwool or similar heat resistant insulating material. Details concerning the stove compartment can be taken from the construction design of apparatus 2 described in fig.6 + 10 - 13.

Apparatus 2

To sterilise quantities of soil ranging from 0,5 - 1 m³ at one time, a separate steam producing unit (steam boiler) is required, (fig.3, 4).

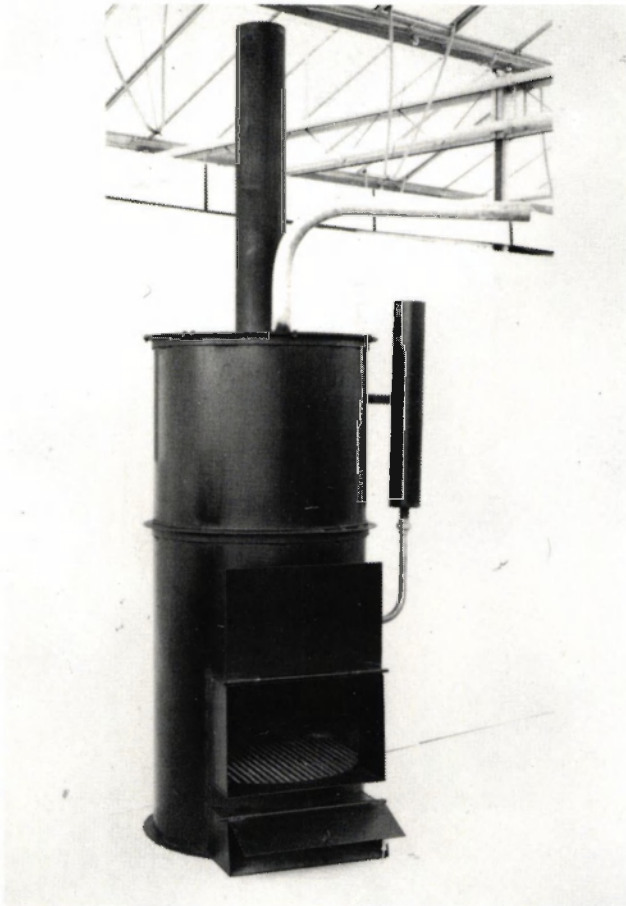


Fig.3 Simple low pressure steam producing unit.

Due to a small overpressure the steam is transported through a perforated pipe that is buried in the soil. This soil may be in a heap of soil or in a container. Whereas this method gives far more possibilities than that described previously, a complete construction design is presented.

The centre part (fig.6, 7) of the steam unit (fig.5) is constructed from a clean oil drum filled with water up to a fixed level.

The filling pipe, connected with the drum, is also acting as water level control and safety-stand pipe. From the top of the drum the steam produced can be discharged via an isolated transport pipe to the soil. The steam production is regulated by

using the fire door and ash pit door at the same time. The fire place underneath the drum is constructed only for the use of wood fuel. The fuel gases escape around the water filled drum to the chimney and warm up the side walls of the water vessel. To promote the efficiency of the apparatus it also can have a double sheet outerwall, with e.g. rockwool in between.

Details of the construction

In the figures 5 to 11 details are given of the different parts of which the steam unit can be constructed. All dimensions are in centimeter (cm); the height "H" and the diameter "D" of the drum are standards which may vary according to the type of drum that has been chosen.

Steel sheet of 2 mm (0,2 cm) thickness can be used for making the outershell, the top lid and the bottom plate. Light weight ready made pipe can be used for the funnel. For the discharge steampipe and the perforated soil pipe normal steampipe is used, but no smaller than 5,1 cm inside diameter. In the perforated part three series of 2 mm holes were drilled (see fig.4). Two drain cocks are needed to drain the condensed water out of the steam pipe. To prevent early condensation the discharge pipe has to be isolated.

The union between the steam pipe and the drum must be fixed steam tight.

Near the bottom a $\frac{1}{2}$ " socket is welded on for the filling pipe.

The drum is placed upon stays in the middle of the shell.

The fire grate consists of two parts and is made of square iron (1 x 1 cm) with a spacing of 1,5 cm between the bars. The stays (0,6 x 2,5 cm iron) for the grate and the steam vessel are welded on the outer shell.

Final remarks

The presented design for a low pressure steam unit can be modified in several ways, the one described is an example of one method of construction.

For easy operation in different places it is advisable to mount the apparatus on wheels or a lorry, especially when steam sterilisation of soils on the spot is required. In that case a suitable grid for steam injection should be available. The apparatus presented are made for wood fuel only, therefore adaption of the combustion room can be made for the use of paraffin or other fluid or gaseous fuel.

Literature

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Appendix: figures

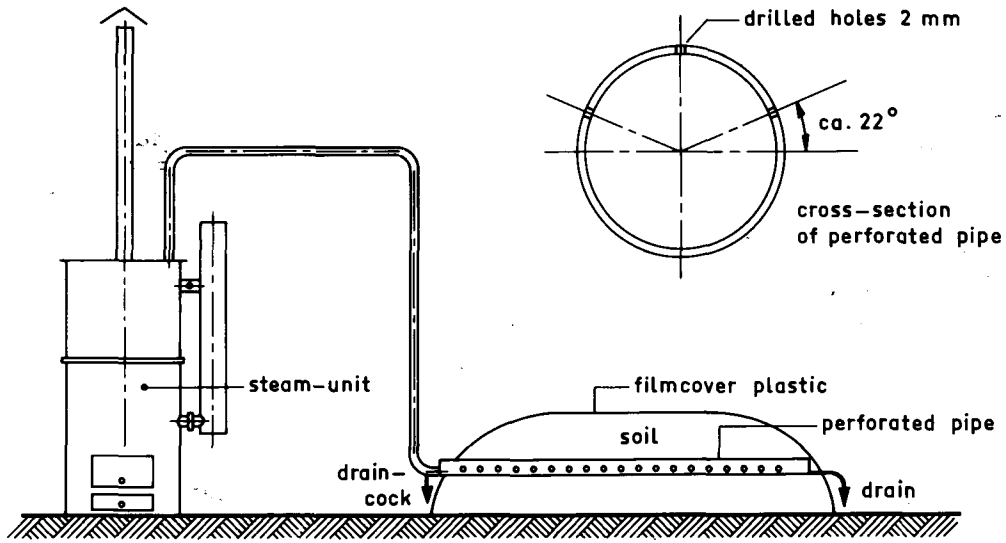


Fig. 4

Arrangement of simple low pressure steam-unit for soil sterilization.

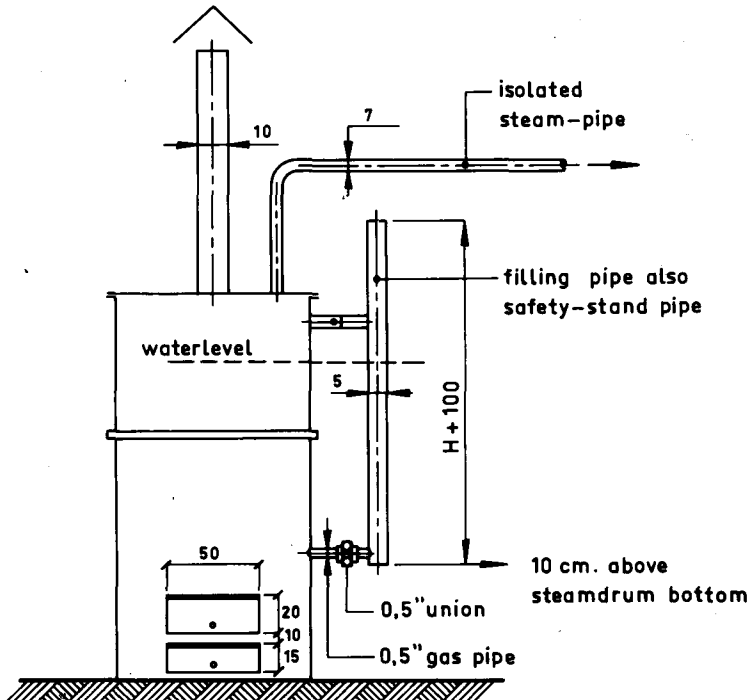
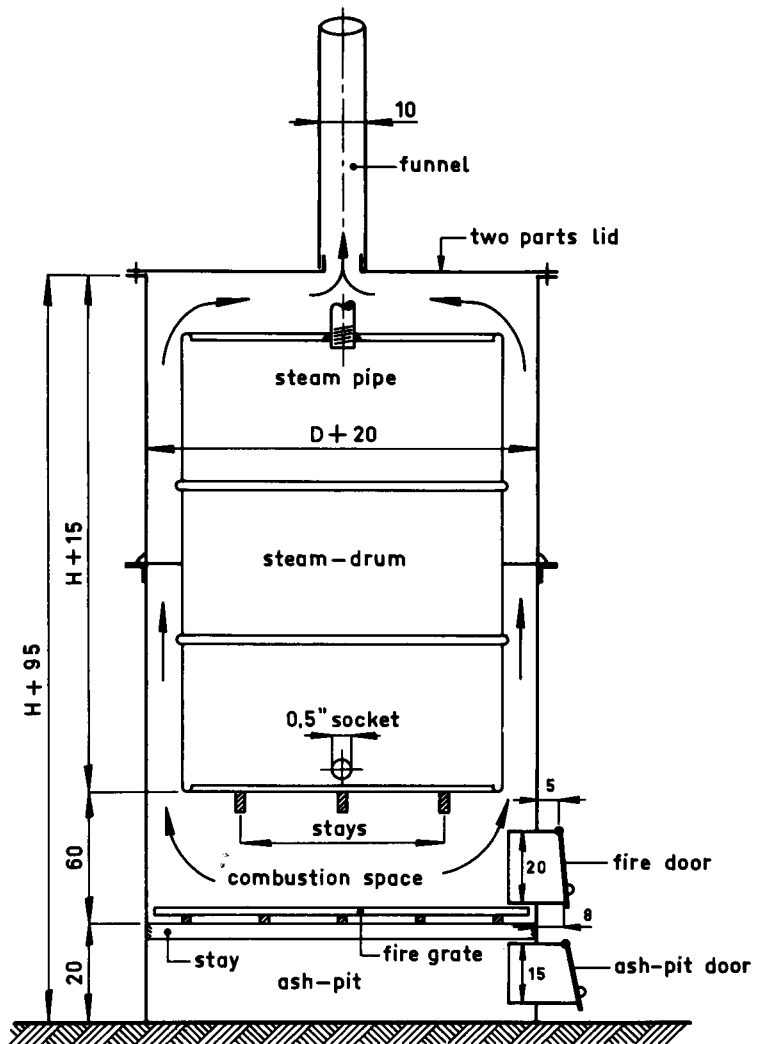


Fig. 5

Steam-unit

Fig. 6



Cross-section of steam unit.

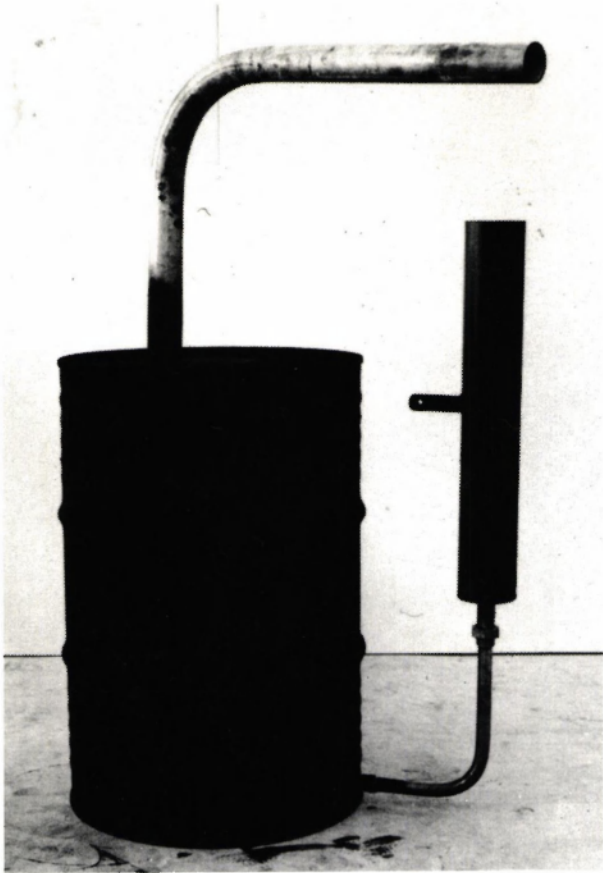


Fig. 7 Oil drum used as steam vessel with filling and steam discharge pipe.

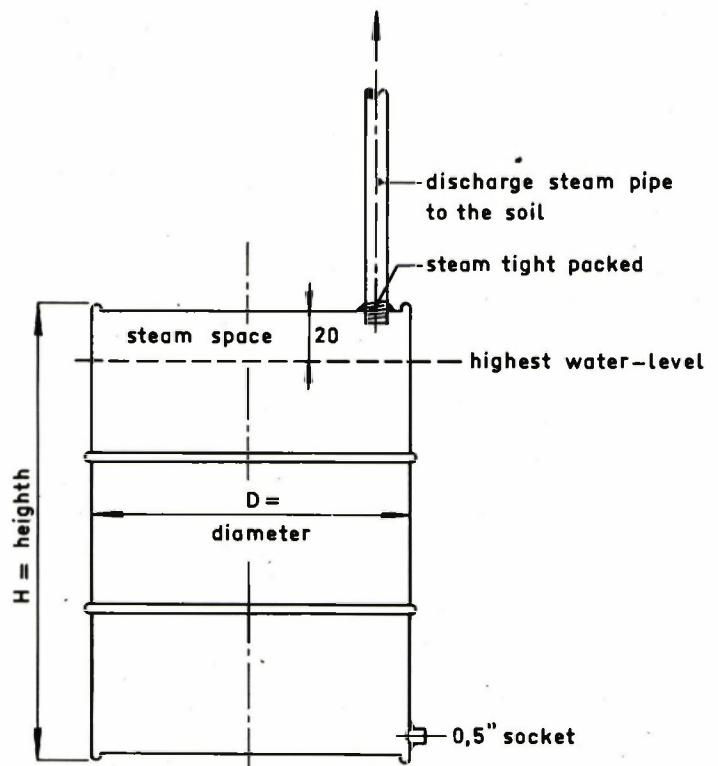
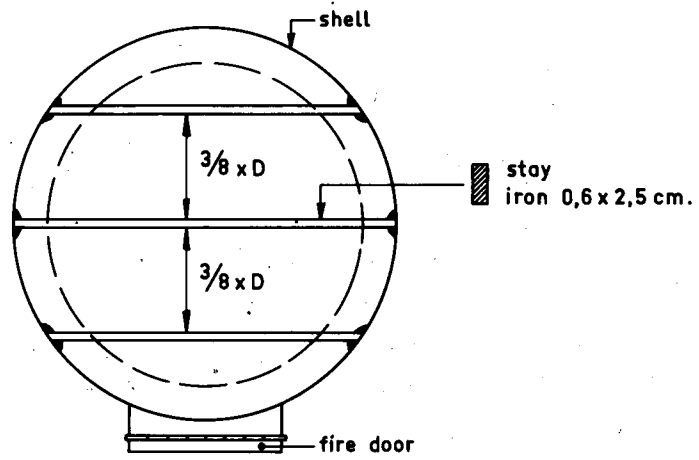


Fig. 8

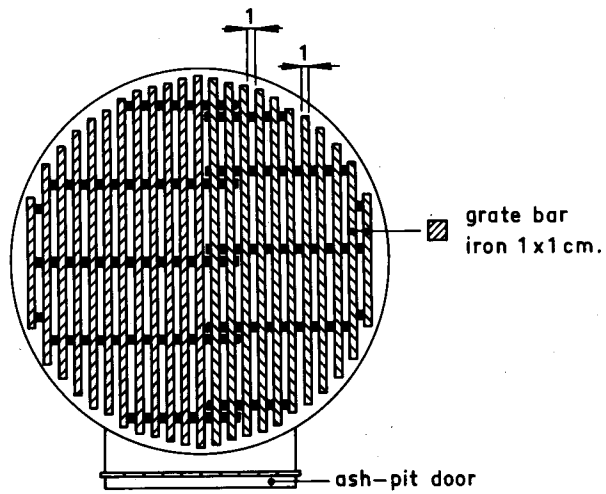
Steam-drum

Fig. 9



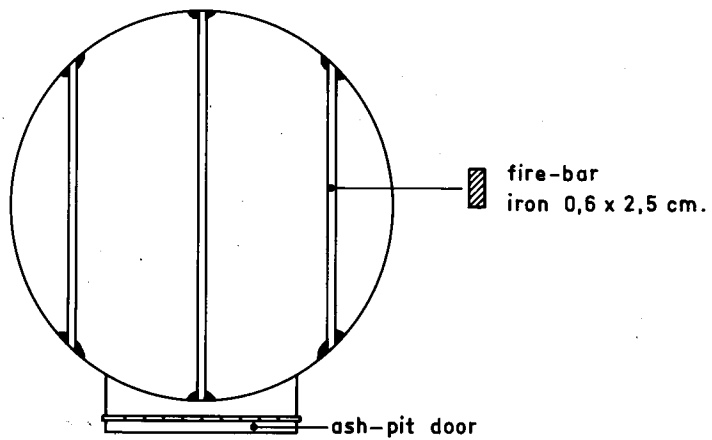
Stays for steam-drum.

Fig. 10



Fire grate.

Fig. 11



Stays for fire-grate.



Fig.12 Top inside view on the stays for the steam drum and the fire grate.

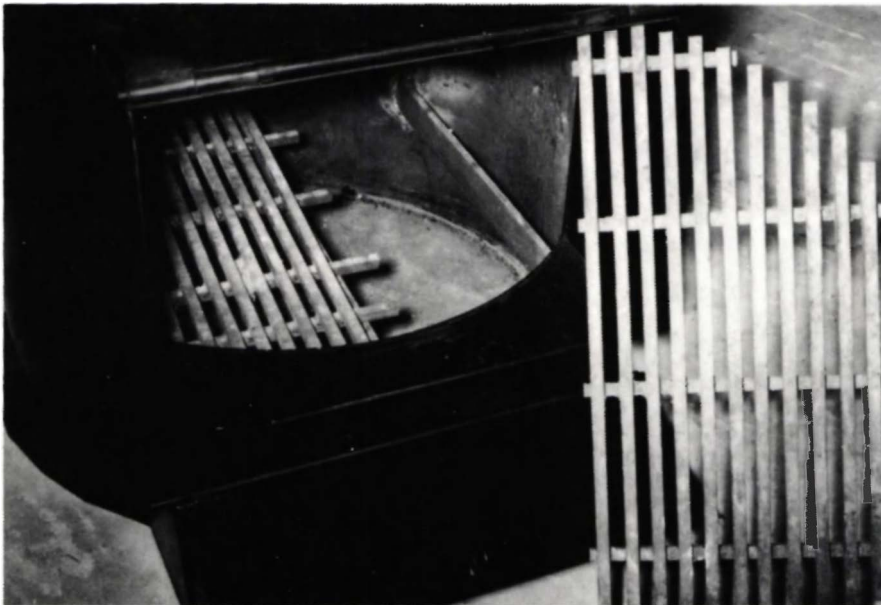


Fig.13 Inside view through the fire door with the two parts fire grate.