EXPERIMENTS WITH A NEW TYPE OF SMOKE-HOUSE

BY

J. H. PIDDLESDEN

Introduction

Although the "Subur" type smoke-house (1) which has been recommended by the Institute for the last two or three years marked a distinct advance on the older types of smoke-house, it has been felt for some time both by ourselves and various estate engineers and managers that it could be improved upon. Experiments have been in progress on the Institute's Experiment Station for a year to this end and at the same time a number of smoke-houses of new types have been built independently by estates. It is intended in this paper to give a brief description of some of these estate buildings together with an account of the experiments made by the Institute and details of the type of smoke-house which has been finally evolved as a result of them.

One of the main objections to the Subur type smoke-house is the necessity of utilising turn-tables and moving the rubber from one chamber to the next each day. A straight rail-track running through a building of the tunnel type is the obvious solution, but this involves forfeiting the separate independent control of temperature which is one of the main features of the earlier type with its separate compartment for each day's sheet. This has not proved as serious as was at first feared, since experience has shewn that although by such control the drying can be carried out more efficiently and quickly, speed is not the only factor in curing sheet rubber. Although sheet can be dried in three days in a Subur smoke-house, four days is considered necessary for adequate smoking. The close temperature control made available by this type of buildings is not therefore vitally necessary and is not in fact generally used to the full.

Another objection to the Subur type is that of cost. Elimination of the turn-tables and interior partition walls would save some of this outlay, as would a reduction in the number of doors. The brick building remains expensive in spite of such modifications. Resistance to fire was the main reason for which the brick and steel construction was widely adopted. Experience has shewn that this risk arises more from lack of care in firing and from the accumulation of inflammable gases than from the use of inflammable building materials. Smoke-houses built of bamboo and paper have been used successfully for over two years

at the Institute's Experiment Station, and buildings constructed of similar materials are still in use after a number of years on several large estates in Java. On the other hand, a number of brick smoke-houses have been burnt in this country in the last few years. It is true that in some cases it has been possible to salvage much of the material and rebuild the smoke-house, whereas a wooden building would have been completely destroyed, but the cost of such reconstruction may easily be as great as that of building an entirely new smoke-house of cheaper materials. A well-constructed cavity-wall with wooden planks on the outside and a suitable insulating board forming the inside surface gives quite satisfactory heat insulation and is much cheaper than brick. It is therefore suggested that this type of construction is suitable for tunnel-type smoke-houses.

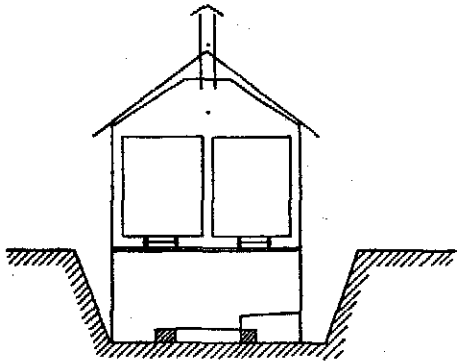
Some Tunnel-type Smoke-houses in Use on Estates

TYPE 1. (*See Figure 1*)

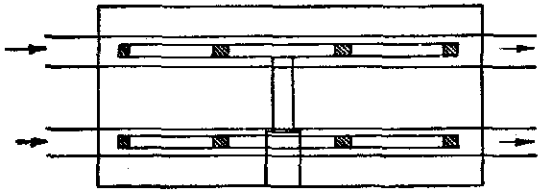
Probably the first design utilising this straight-through principle was the one using a separate building for each day's crop. Two, three, or four buildings may be used spanning a single or double rail-track. The furnaces are usually half-way along the side of each building and may be inside or outside the side walls. In all cases the furnace is well below ground level. The ground may be excavated down to furnace level right round the outside walls; it may be excavated over the whole area of the inside of the chamber only, using the side walls as earth retaining walls; or space for the flues only may be dug out. One well-known design which employs steam heating and dries the rubber in two days follows this system of a separate building for each day's drying with a straight-through rail system.

This system of separate buildings is excellent for large estates manufacturing over two tons of rubber per day, for here several buildings and furnaces would be needed in any case and the method of operation is simpler than that required for a number of separate smoke-houses, each drying a portion of the crop completely. For a small estate with a yield of 2,000 lb. or less per day, where only two trolleys per day are needed it is obviously uneconomic to erect three or four separate buildings with a corresponding number of furnaces, doors, etc. For small units attempts have been made to work with only two buildings, leaving the rubber in each one for two days. This has proved successful, but does not appear to offer any advantage over the Subur type either in first cost or in running cost. Outline sketches of this type appear in Figure 1.

TYPE 1

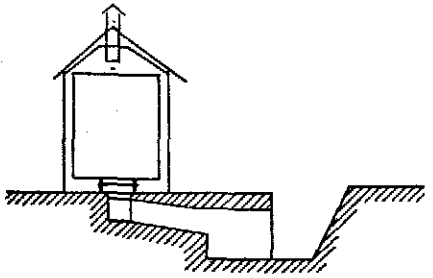


END ELEVATION

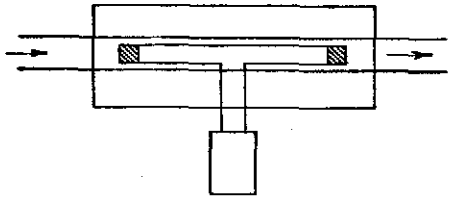


PLAN

LARGE UNIT



END ELEVATION

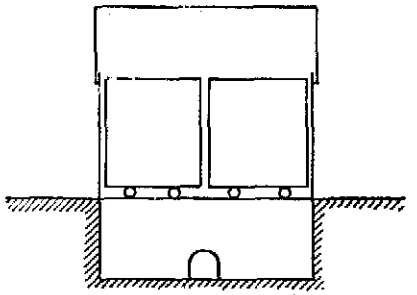


PLAN

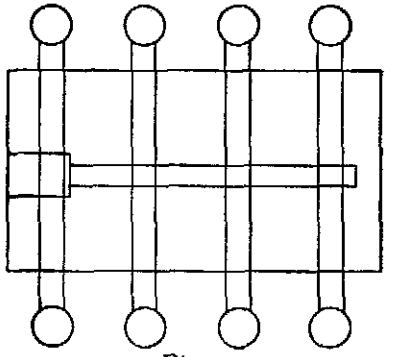
SMALL UNIT

FIG. 1

TYPE 2



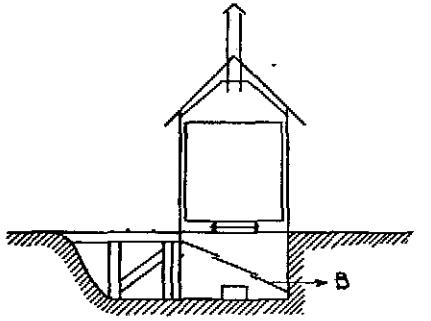
END ELEVATION



PLAN

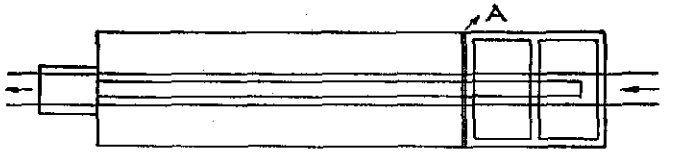
FIG. 2

TYPE 3



END ELEVATION

A. INNER DOORS
B. DRAIN BAFFLES.



PLAN

BERADIN TYPE

FIG. 3

TYPE 2. (*See Figure 2*)

Another type of smoke-house which has appeared on one or two estates and is said to work satisfactorily is a straight-through type in which the flue, in an underground chamber, runs at right-angles to the rails of which four sets are generally used. It resembles the Subur type but has doors at the front and back, and has a lower flue chamber excavated to a depth of about six feet over the whole area of the house with the flue built up on the floor of this chamber. It has the advantage that it can be extended almost indefinitely. The large deep flue chamber is necessary to obtain a uniform distribution of temperature. In a large unit it may be possible to get increasing temperatures as the rubber passes through the house, but for small buildings using only one flue this cannot be done and temperature variations through the house must in fact be kept to a minimum for successful working.

TYPE 3. (*See Figure 3*)

In this general type the underground flue runs parallel to the single or double rail-track, and the furnace is at one end under the rails. Several variants of this type have been erected, differing in details of design and in the amount of excavation carried out. The most interesting example is perhaps that built on Beradin Estate and described in the *Straits Times* for December 31st, 1937. This building incorporates several new and useful ideas. The trucks were made wide in comparison with their length, so that eight trucks can be accommodated on a single track inside the building without the latter having to be made excessively long. The building is divided into two compartments at a point three-quarters of its length from the furnace end, by means of a brick partition across the lower flue chamber, and doors across the upper smoking chamber. The wet sheet is thus isolated for the first 24 hours from the remainder of the rubber in the smoke-house. In this first compartment there is a sloping baffle running across the house below the rails to collect any drippings. These are drained off through a gully and outlet pipe. The trucks are 10 feet wide, 6 feet long, and 9 feet 6 inches high and run on a 3 feet 6 inches gauge rail-track through the tunnel, which is approximately 52 feet long and 12 feet wide. The floor of the lower chamber is 6 feet below rail level and carries a horizontal rectangular flue 18 inches wide by 2 feet deep.

All of the buildings described are working satisfactorily and some of them are simpler to control and operate than the Subur type. The cost was usually of the same order as that of the Subur, except where cheaper materials of construction were used, or

where the house was designed for a large capacity, in which case the capital cost per 1,000 lb. of rubber could be reduced. They are all characterised by one disadvantage in that they required a considerable amount of excavation, which renders it extremely expensive, if not impossible, to build them on sites where the water-table is high.

Experiments at R.R.I. Experiment Station

An attempt was made to design a tunnel smoke-house which would not involve costly deep excavation and which would for this reason be suitable even for wet sites. It had long been realised that the hot gases escaping from the smoke-house when the rubber was almost completely dry were far from saturated, and it therefore seemed probable that economies could be effected by passing these gases through the wet rubber, and it was resolved to incorporate this idea in the design. A simple tunnel was therefore built large enough to hold four trucks each carrying about 600 lb. of rubber. Cavity-walls with wood on the outside and an asbestos-cement board as the lining were used. The roof was of corrugated iron with a flat inner ceiling, and thin sheet baffles were loosely attached to one end of each truck. The furnace consisted of an oil drum, insulated with boiler composition sunk just far enough into the ground to enable the flue pipe to pass under the rails. The chimney was arranged to draw off from below the centre of the truck at the cooler end. The resulting arrangement is shewn diagrammatically in Figure 4.

Many attempts were made to make this system work by alterations to the chimney and furnace, application of heat at the base of the chimney to induce draught etc., but the results were all disappointing. It proved impossible to get sufficient draught through the smoke-house and the end remote from the chimney remained cold. The baffles were removed from between the trucks in an attempt to get a straight horizontal flow of hot gas, also without success. One of the reasons for trying to obtain down-draught through the truck remote from the fire was that if this could be achieved, the ceiling would be warmer than the floor at this end, so that any condensation which occurred would tend to take place first on the floor. It was thought that this would help to overcome the difficulty which has been experienced in some smoke-houses where moisture has condensed on the ceiling, dripped back and stained the rubber.

The next step was to blank-off the chimney and to instal a ventilator over the end truck. This gave slightly more promising

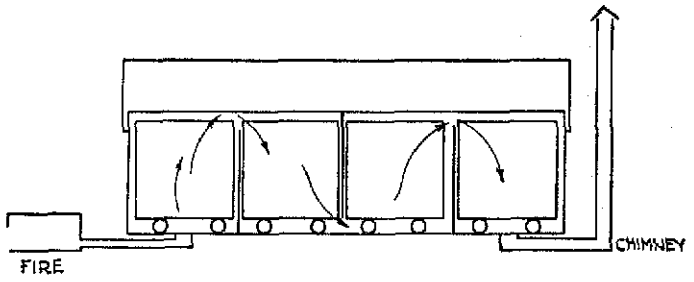
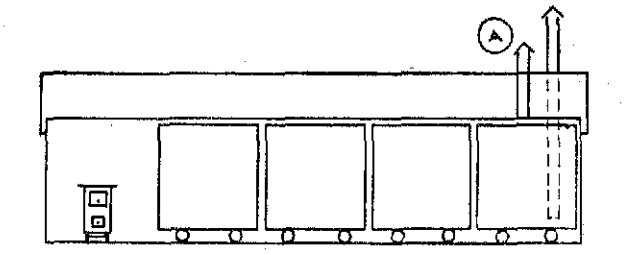
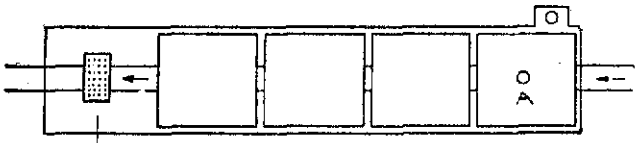


FIG. 4

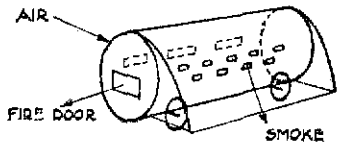


ELEVATION

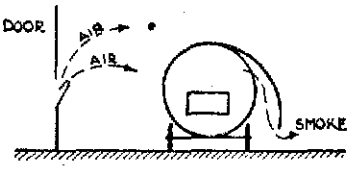


PLAN

FIG. 5



PERSPECTIVE



ELEVATION

FIG. 6

results, and by this means is was possible to get a few of the sheets on the top racks dry in four days. The heat inside the smoke-house was still insufficient however, and it was therefore decided to try a fire inside the building. One truck was accordingly omitted and its place was taken by a firebox constructed from an old oil drum mounted horizontally on wheels. This appeared to be more successful, but still most of the heat and smoke appeared to be close to the ceiling.

At this stage the building was re-modelled. The length was increased by eight feet so that it would contain the firebox and four trucks. A small bay was built on to the side to contain a chimney in a renewed attempt to draw off the gases from near the floor, in order to obtain a more uniform vertical distribution of heat in the building. At the same time a more permanent firebox was installed consisting of a vertical rectangular box on wheels with firebars at the bottom, a fire door in the side and holes in the top for the smoke to escape. Air was admitted through ventilators in the doors of the tunnel at the furnace end. There was also a small side door in the tunnel through which the firebox could be withdrawn for stoking. The general arrangement is shewn in Figure 5. This system worked at first only with ventilator A (figure 5) opened, and under these conditions it was impossible to get the sheet on the lower racks dry. A number of tests were carried out and by adjustment to the air inlets, the use of a baffle over the smoke outlets on the firebox, and a further baffle across the tunnel between the fire and the first truck reaching from the ceiling to within one foot of the floor it was found possible to dispense with ventilator A. There still remained a marked difference in rate of drying and final colour of the rubber between that from the top and bottom of each truck.

In order to force the smoke nearer the floor the firebox was again changed for a horizontal drum. This was constructed with air inlets on the side nearer the doors and smoke outlets as low down as possible on the side near the rubber. A cowl was fitted over the smoke outlets to force the smoke down. Cowls were also fitted over the air inlets in the doors to send the incoming air up over the fire drum, as shewn in Figure 6.

A large number of trials were carried out with this arrangement on varying types of sheet and with various alterations to the holes in the fire drum, height of chimney etc. It was found that sheet could be dried successfully in four days and that the fuel economy was good. It was still not possible to get a uniform colour on the sheet. That from the top racks was much darker than that dried on the lower tiers of the trucks. Another difficulty was that the proximity of the fire-box to the rubber rendered the temperature control very sensitive. Very careful control of the

firing was necessary to maintain a steady temperature. The wood used had to be cut very small and added at frequent intervals. If larger pieces were used the temperature rose and fell between wide limits. We were therefore very reluctantly forced to the conclusion that a tunnel smoke-house of this type with the furnace above ground level could not be recommended with full confidence for estate use. It has since come to our notice that one estate is operating a smoke-house on these lines (2), but in this case six days are allowed for drying and it is stated that "the bottom racks are used only in emergency."

Experiments with Underground Flues

Attention was now turned to designs in which the smoke and hot gases were led in by flues under the floor level. It was considered essential to reduce excavation to a minimum and the flues were therefore constructed as open troughs covered in with precast concrete slabs. The floor of the firebox and flue was made as near to the surface of the ground as was possible. The firebox was placed at the side, with an inlet flue 18 inches wide by 18 inches deep leading in to the smoke-house between the third and fourth trucks. This joined a one-foot-wide flue running between the rails, with a one-foot-square outlet below the centre of each truck. The flue was 18 inches deep at its lowest point and 12 inches deep at the ends. The trucks were fitted with an arched metal baffle fitted low down and running the full length of each truck, spanning the centre 2 feet 6 inches of their width. These served not only to spread the smoke but to throw off to the side, clear of the rails and flue, any water dripped from the sheet. The floor on each side of the rails was sloped towards the side walls, where there was a shallow drain to take off any water. The features briefly described here were retained in the house in its final form, and further details appear with the plans in the appendix to this article. It was desired at this stage to avoid the expense of changing the flat ceiling for one which would follow the line of the roof and funnel-shaped ventilators were therefore used, one being installed over the centre of each truck. (See Figure 7). Control was readily effected by suspending a circular plate slightly larger in diameter than the outlet pipe in the funnel portion. This device is described, as it gives a very cheap satisfactory controllable ventilator for use with flat ceilings.

Furnace

The furnace consisted of an oil drum packed round with sand Provision was made to admit air between the top of the drum and and enclosed in a brick box with a reinforced concrete top.

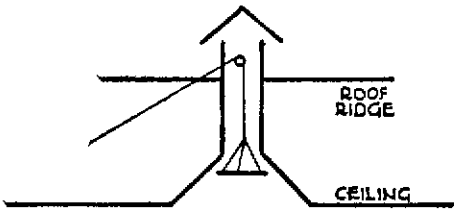
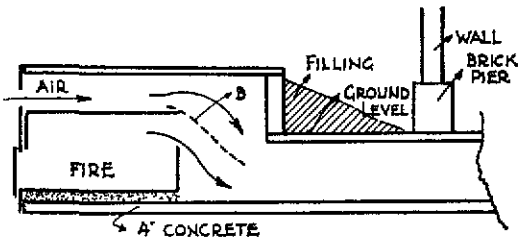
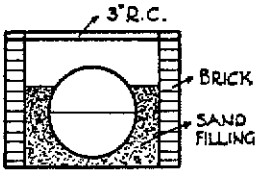


FIG. 7.



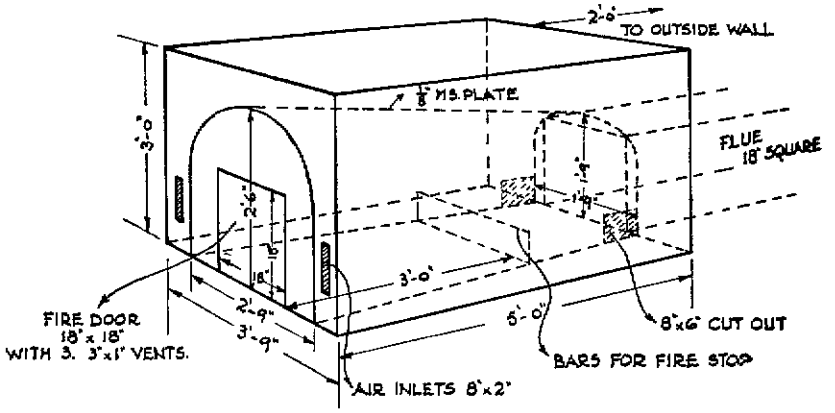
END ELEVATION SECTION



FRONT ELEVATION SECTION

FIRE BOX

FIG. 8.



INSIDE DIMENSIONS SHEWN
SIDE WALLS 4½" BRICK
TOP 3" REINFORCED CONCRETE.

PERSPECTIVE SKETCH OF METAL ARCH FURNACE.

FIG. 9.

the concrete top, with the double object of preheating the air and cooling the top of the firebox. The assembly was completed by a steel face-plate which was bolted on and contained the fire door. Since the walls were only of single brick, and there were no arches or firebrick used, this gave a very cheap furnace. The arrangement can be seen in Figure 8. At its lowest point the furnace and main flue was only 18 inches below ground level.

When this system was first put into operation it was found that the air intake over the fire did not work satisfactorily and that instead of drawing in air, the fire tended to burn back over the top of the drum. The installation of a baffle (B. Figure 8) improved matters in this respect, but the draught through this air aperture remained rather uncertain. Also in the early stages the fire gave volumes of smoke but barely sufficient heat. When it had been in continuous operation for a week and become thoroughly dried out, the furnace structure became very hot. The house then worked very successfully from the drying point of view, the desired temperatures were easily attained and could be kept remarkably steady with very little supervision of the labourer responsible for the stoking. The fire however produced practically no smoke. All attempts to overcome this objection, by careful control of the amount of air admitted to the fire, alterations in the fuel mixture, and in thickness of the sheet used for tests gave only small improvements in the colour of the finished sheet. When the tests were interrupted for several days and the house was restarted from cold it was found that volumes of smoke were again produced for the first day or two. This indicated that the absence of smoke was due to the high temperature and heat-retaining capacity of the furnace structure, which seemed to get sufficiently hot to burn up the smoke from any freshly-inserted wood. A consideration of other smoke-houses which are in regular use confirmed this view. Buildings having massive brick or firebrick furnace structures, such as the Subur type, almost invariably give pale sheet, whereas those having sheet steel furnaces not surrounded by earth, brick, or lagging, give much more smoke.

The drum and sand packing were therefore removed from the furnace shell and replaced by a tapered arch of thin sheet metal which rested freely on the furnace floor and was well clear of the walls and top. Air inlets were cut at each side of the face-plate low down between the arch and the wall. The metal arch was long enough to reach right back to the furnace end of the main flue. It contained two or three bars to act as fire stops at about two feet from the flue and had an air-hole cut out low down on each side at the back, to enable the air which had travelled along outside the arch to enter the flue. A perspective

PLATE I. Side view of Building showing Furnace.

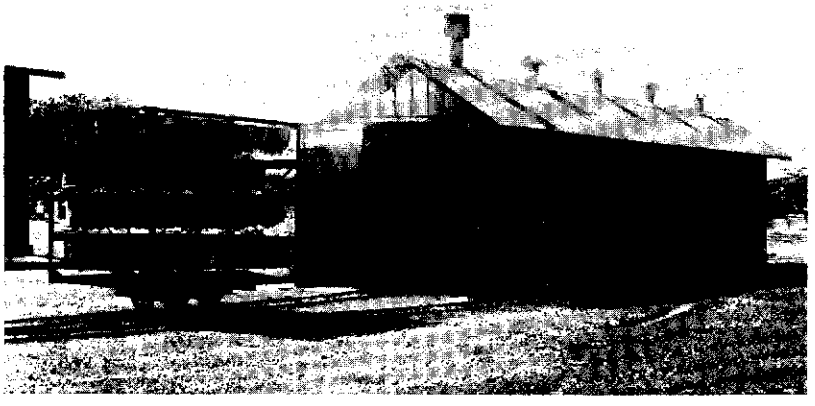


PLATE II. Reverse side showing Return Rail Line.

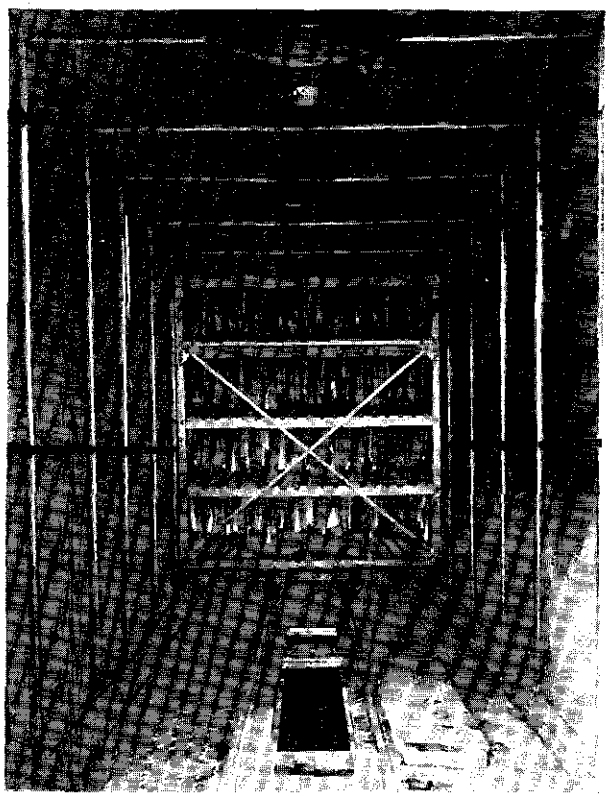


PLATE III

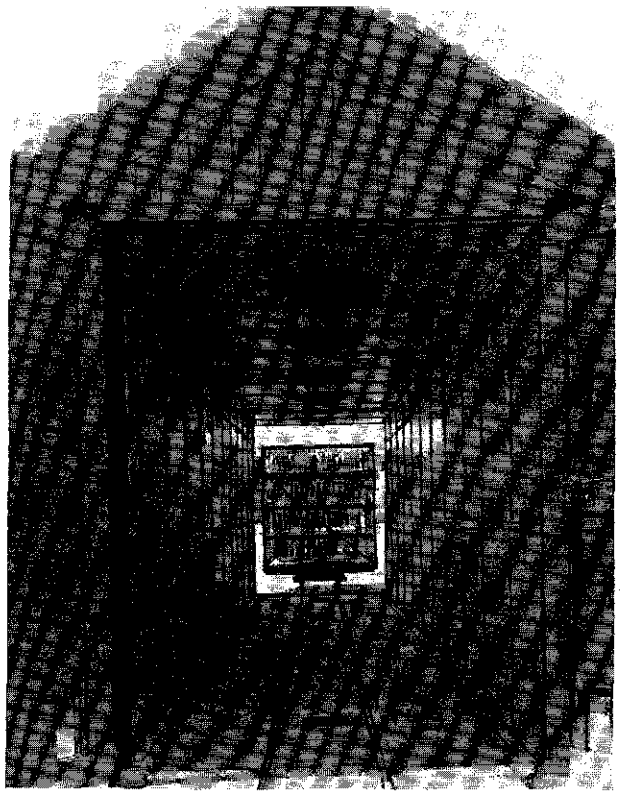


PLATE IV

Views of Interior of Tunnel.

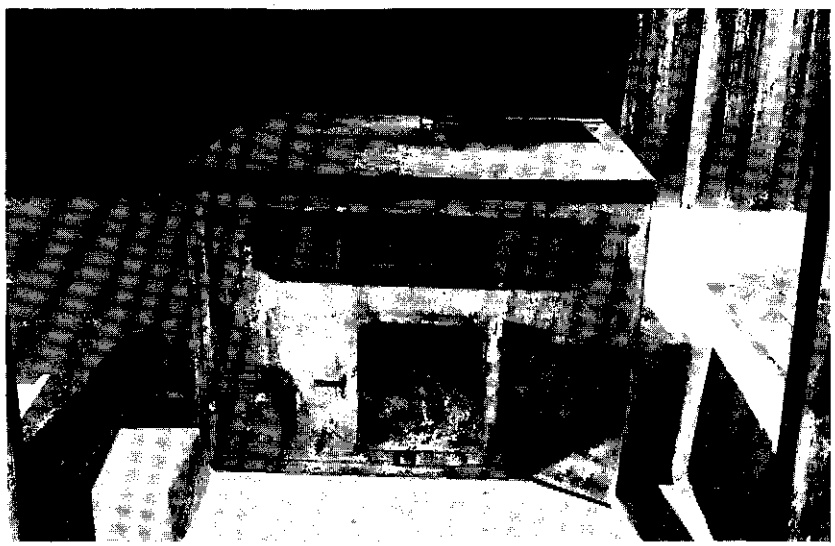


PLATE V
Furnace opened shewing Inner Arch.

sketch of this arrangement is shewn in Figure 9. This system was found to work excellently. By adjustment of the flue apertures and top ventilators it was found easily possible to obtain a temperature gradient of 20°F to 25°F along the house, and when they were once set these controls needed no further adjustment over a long series of tests, in which a number of different varieties of estate sheet were dried. There were no ventilators round the base of the walls and the only remaining adjustments necessary were the amount of fuel, amount of air admitted through the fire door, and the amount of air entering round the outside of the metal furnace arch. Sheet varying in thickness from 0.09 inch to 0.15 inch was all dried to a good medium brown colour in four days. The temperatures could be held remarkably steady, the furnace gave a good volume of smoke, and the outer brick structure kept much cooler than in the previous tests. In the experimental model no firebrick was used, the metal arch was only of 18 gauge galvanised sheet and the face-plate was of 1/8" mild steel. In spite of this flimsy construction the furnace has worked practically continuously for several months and remains in very good condition. A slight bulging of the furnace face-plate occurred in the earlier tests when the drum was used, but no further distortion appears to have occurred. Photographs of the experimental building in its final form appear in Plates I to V.

New Smoke-houses

As a result of these tests two smoke-houses have been designed for estate use and are described in an Appendix to this paper. The first follows very closely the experimental model, and is designed for a crop of up to 1,000 lb. per day. It is considered to have been tested thoroughly and can be recommended to estates. The second model is designed as a unit capable of drying 2,000 lb. of rubber per day. The principle is exactly the same, except that eight trucks are used on a single track, and in order to prevent the flues from becoming excessively long the wide short trucks, similar to those described in connection with the Beradin smoke-house, are employed. This model has not yet been put into operation, since the means for testing it are not available at the Experiment Station. The design is put forward however with some confidence; it is hoped that an estate will erect such a building on which tests can be made by the Institute for early publication. The fuel consumption in the experimental model is very slightly more than ½ lb. of wood per lb. of dry rubber produced, and it is confidently expected that this can be improved upon in the large unit.

These new smoke-houses offer several advantages over previous types. They can be built on sites where the water table is high. The initial cost for the building is low if timber and insulating board are used, and even with a brick building the cost is less than that of the Subur type. The furnace is of cheap and simple construction and can readily be renewed by the insertion of a spare steel arch. Such work would not require skilled labour. The operation is simpler than that of a Subur-type building, and the rubber produced is a much more satisfactory colour. The production of a well-smoked sheet is of particular importance if rubber is to be stored for any length of time, as the smoke tends to increase the resistance to mould attack.

In addition to the two new smoke-house designs put forward as a result of this work, the difficulty of obtaining an adequate volume of smoke, and a sufficiently dark colour on the sheet dried in smoke-houses with an exterior furnace, appears to have been overcome. The tendency has been to make such furnaces more and more massive, with the object of securing a longer life and reducing the proportion of heat lost to the outside air. Every increase in the thickness and insulating properties of the furnace walls has resulted in an increase of temperature of the inner surface of the furnace and in the heat capacity of the structure, until it has become common to find furnaces which require days to heat up to an equilibrium condition or to cool to air-temperature after the fire has been withdrawn. The exceptional wall-temperatures have rendered the use of refractory furnace linings necessary and have also made it very difficult to produce smoke. In spite of numerous experiments with various fuels, and alterations in the supply of primary air, any smoke produced from the wood becomes burnt up on striking the extremely hot furnace arch. These objections can be overcome by using a thin walled furnace but in that case the heat loss would be very large. The present design gives the thin cool furnace walls and at the same time transmits radiant heat to the ventilating air. The arrangement has the additional advantage that the ventilating air and hot gases from the combustion become mixed in the flue and enter the drying chamber together, thus tending to give a more uniform temperature distribution than the older method which admitted hot flue gases in the centre of the chamber, while cold air entered through ports in the side walls.

The principle of the steel inner arch separated from the main furnace structure with a stream of air passing between the two can easily be applied to the furnaces in existing Subur smoke-houses. Such a modification has not yet been thoroughly tested, but has already been recommended to a few estates, and sufficient confidence is felt to propose it for the consideration of

others who are not satisfied by the colour of sheet produced in smoke-houses of the Subur type.

Acknowledgments

The author is indebted to Dr. E. Rhodes, formerly Head of the Chemical Division, and to Mr. H. W. Foston, Manager of the Experiment Station, for their continued interest, advice and help in this work. Our thanks are also due to the General Manager of the Kepong (Malay) Rubber Company and his estate Managers for supplying representative samples of sheet rubber from various estates for our tests.

Literature Cited

(1) Moore, A. and Piddlesden, J. H., *J.R.R.I.M.* **7** (1937) 147.

(2) Planting Correspondent, *Straits Times,* Jan. 14, 1938.

Kuala Lumpur

15th September, 1938