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A LOCALLY MADE STONE MILL**

Prepared by

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* Organized by UNIDO in co-operation with the Government of Zambia and the Village Industry Service

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Introduction

The processing of food grain plays an important economic role in Sudan for two reasons. Firstly, processed grain food is a very important element in the diet of low-income groups, especially in urban areas where there is no equipment to perform the basic processing of agricultural and animal products. Secondly, the use of appropriate technologies to process the grain may further achieve socio-economic objectives, such as employment generation and the saving of scarce foreign exchange.

The stone mill is an example of locally manufactured food processing equipment in Sudan. It has been constructed in a private machine shop. To have locally manufactured equipment, there must be skilled manpower and good know-how, available raw materials and well-equipped machine shops.

1. Skilled manpower and know-how

The beginning of this century has witnessed the erection of the first machine shop in Sudan. The purpose of the machine shop was to produce essential spare parts and machine elements for Sudan Railways. Accordingly, a technical school was opened to provide skilled, trained manpower to the machine shop. This machine shop influenced industrial development in the Sudan. There are now more than 100 secondary technical schools and 25 high-technical institutes. Four engineering colleges have been established. As a result of this development, skilled manpower has exceeded the local demand.

2. Availability of raw materials

Cast iron, brass and mild steel are not the most common materials required in machines and in the equipment manufacture. Recently several foundaries have been developed to meet the demand of local industry. Electrical furnaces have gradually replaced the diesel ones; overhead cranes have replaced the manual operation of materials. These developments in foundaries have eliminated the problems of cast iron and brass. Only mild steel is imported.

3. Machines and equipment

The government organized well-equipped machines shops to cover the needs of big governmental enterprises, such as Sudan Railways, Sugar Plant and El Gazira Board. These shops do not include the manufacture of food processing equipment. Fully-stocked machine shops handling such equipment are found in the private sector.

Design of food processing equipment

Many food processing operations frequently require the breakdown of solids through the application of mechanical forces. One such mechanical force is cereals milling.

The size reduction of solids generally involves three types of forces. Those predominating forces in commonly used mills in the food industry are summarized below:

Force	Principle	Machine
Compressive	Compression (nut cracker)	Crushing rolls
Impact	Impact (hammer)	Hammer mill
Shear (attrition)	Attrition (grindstone)	Stone mill

The third type of force is extensively used in machines for the comminution of softer, nonabrasive materials of smaller sizes, i.e. fine grinding.

Milling techniques used in Sudan

The three distinct milling techniques used in Sudan are:

1. the motor-and-pestle technique used in the household;
2. the engine-powered hammer mills and stone mills, equipped with diesel or electric engines and used by custom mills and merchants mills to produce whole meal; and
3. the roller mills (This paper discusses the grain stone mill.).

Description of stone mills

In a typical stone mill, a conical- or pyramid-shaped hopper holds the whole grain, which enters the milling chamber through a feed valve. In some models, a shaking device and a screen prevent large impurities from entering the milling chamber. The shearing action of the flat surfaces of two identical millstones performs the milling of the grain. One stone is fixed to the milling chamber while the other stone is mounted on a rotating drive shaft connected to an external energy source (e.g. an electric motor, diesel engine or tractor engine). Figure 1 illustrates the basic design of a stone mill.

The grain from the hopper is fed through the central hole in the rotating stone and then into the gap between the two stones. As the rotating stone moves against the stationary stone, the grain is ground as it travels from the centre to the periphery of the stones. The two millstones may be set vertically with a horizontal rotating shaft, or horizontally with a vertical rotating shaft. The diameter of the millstones varies according to the type and size of the model. Generally, because of the weight of the stones and the relative difficulty in supporting them in an upright position, vertical millstones are smaller in diameter (20-56cm) than the horizontal millstones (61-71cm).

The capacities of electric motors used in stone mills vary between 0.4-15kw, according to mill capacity and the diameter of the millstone. The motor capacity governs the rotation speed of the millstones with a maximum speed of 600-800rpm.

The amount of ground material depends upon the motor capacity, the rotation speed, the millstone diameter, the grain variety and the desired fineness of the ground material. The average output of a vertical stone mill is 80kg/km per hour. Thus, the average output of stone mills varies between 33-1,600kg/h, depending on the motor capacity, the position (vertical or horizontal) and diameter of the millstone, the type of grain and the required fineness of the ground material.

Millstones are made out of one of the following materials:

1. natural stones;

2. small pieces of natural stones embadded in a matrix of cement or other suitable material, such as emery:

3. artificial stones made of emery, carborundum or a mixture of these two materials embedded in a matrix of magnesium oxychloride cement; or

4. additionally heat-treated or vitrified cardorundum for increased durability.

A supporting and protecting metal band encloses all stone types. They are grooved to allow the shearing of the grain, as well as to assist the movement of the grain to the stone periphery.

The casing of most stone mills is made out of cast iron.

Description and specifications of the Sudanese mill

An electric motor runs the mill through three V-belts. It has a vertical spine, which rotates the lower stone. The handwheel of the spring tensioner raises or lowers the lower stone to control the fineness of the flour. The upper stone is fixed and has a larger diameter than the lower stone. The Trading and Contracting Company locally manufactures the stones; the raw material (emery and carborundum) required is imported from Denmark. The mill has a stand with three legs made from mild steel iron angles, which are joined to the body of the machine by riveting and post welding. There are two outlets for flour. A feed control is there for the seeds supply, which has a vibrating butterfly flap.

Specification

Capacity	500kg/h
Electric motor	Three phase, 10hp, 1,500rpm
Pulley	420rpm
Upperstone	71cm
Lower stone	61cm
Hopper	58 x 58cm^2 made from a 1.2 mm mild steel sheet
Lower case	74cm diameter x 32.5cm heighth made from a 1.2mm mild steel sheet
Stand	6.5cm mild steel iron angle and 4 x 8cm^2 iron U-section

Note

Cast-iron parts, such as a main spindle hub, roller bearing guide and top bearing case) are produced in local foundaries.

Figures 1 (vertical stone mill) and 2 (horizontal stone mill) show the parts of the locally made stone mills.

Evaluation

The evaluation study of locally manufactured stone mills was performed by a team from the Industrial Research Consultancy Centre (IRCC).

A comparison of the operation, the efficiency and the price of the locally manufactured stone mill with that of an imported one having the same specifications) from Denmark shows:

1. The price of the locally manufactured stone mill was LS 8,000. The price of the imported stone mill was LS 9,600;
2. The degree of fineness of the product was the same;
3. The locally manufactured mill was more stable (less vibration) during operation; and
4. The locally casted thrust bearing has a longer lifespan than that of the imported mill.

Conclusion

The proper running of custom mills depends on an efficient, organized production and an available, adequate infrastructure.

1. Skill requirements

The running of milling equipment requires skills, which may be quickly learned, for example, on-the-job training. The mill operators need only know how to adjust the mill for grain processing. On the other hand, the repair and maintenance of the equipment require mechanical skills and, in some cases, a minimal knowledge of electricity.

2. Infrastructure requirements

Generally, infrastructure requirements depend on the type and capacity of the mill as well as on the need to store the raw materials and/or output. Depending on the adopted engine, mills may require an electric supply line or a petrol/diesel storage area.

The installation buildings for milling equipment and the storage areas should be well ventilated since the milling process generates a large amount of dust. There should be adequate roofs to protect the grain or flour from rain. The buildings should have cement floors to minimize flour contamination by sand or dirt and to facilitate the cleaning of the floor.

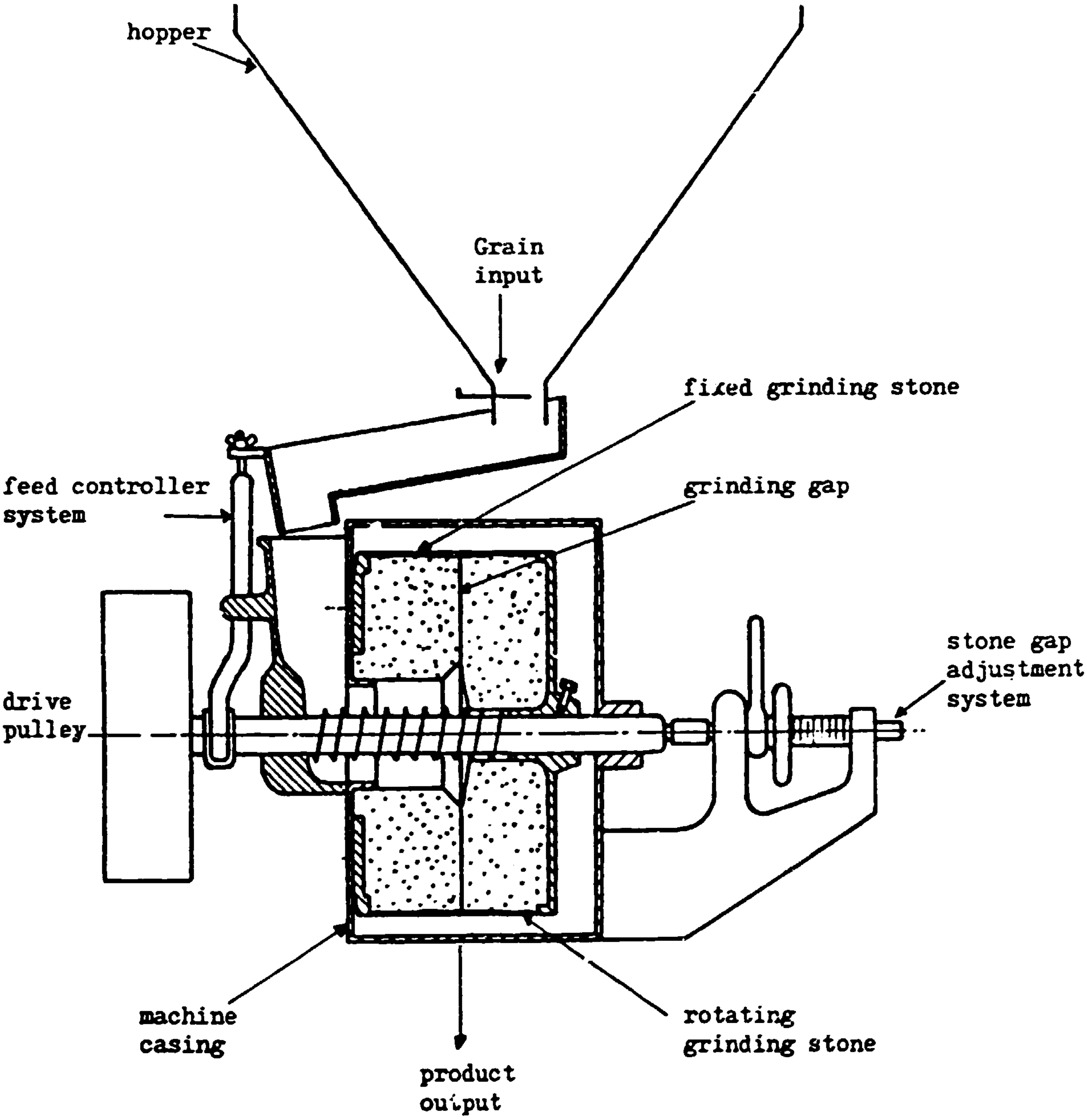


Figure 1

Diagrammatic representation of a mechanical stone mill with vertical grinding stones

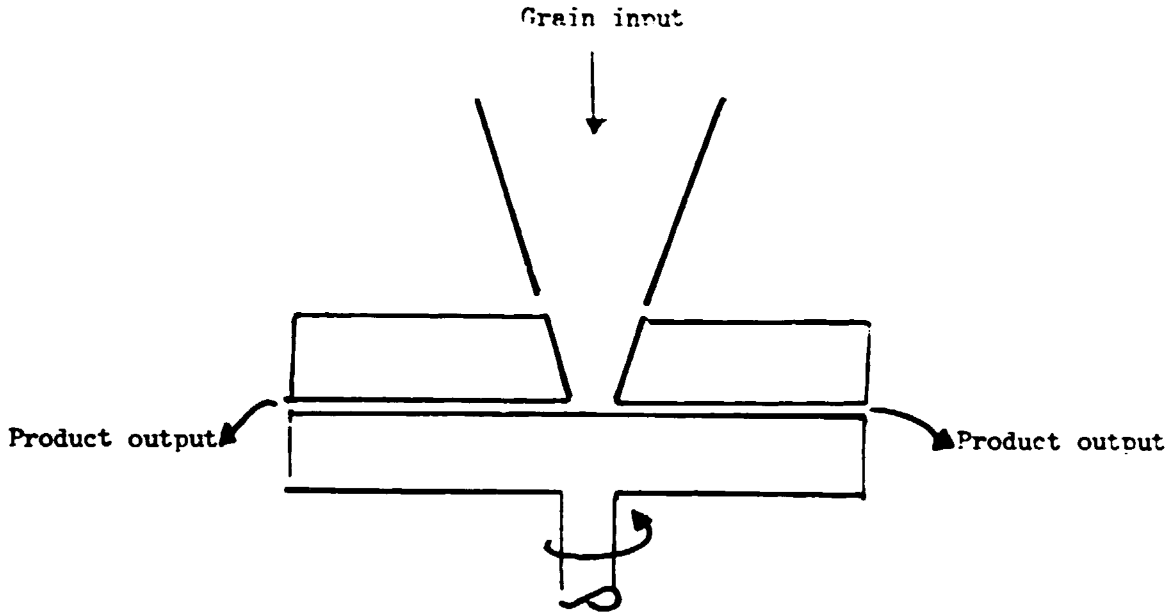


Figure 2.1 Stone mill diagram

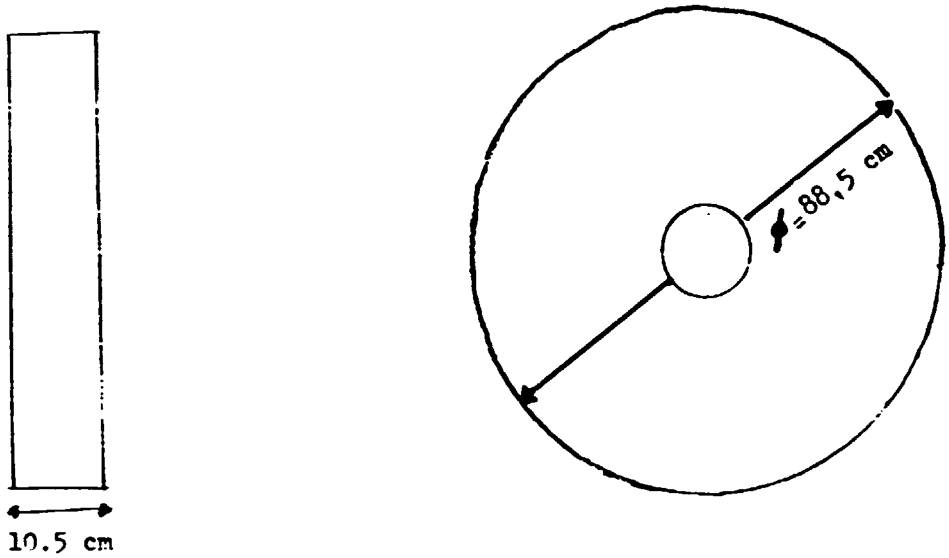


Figure 2.2

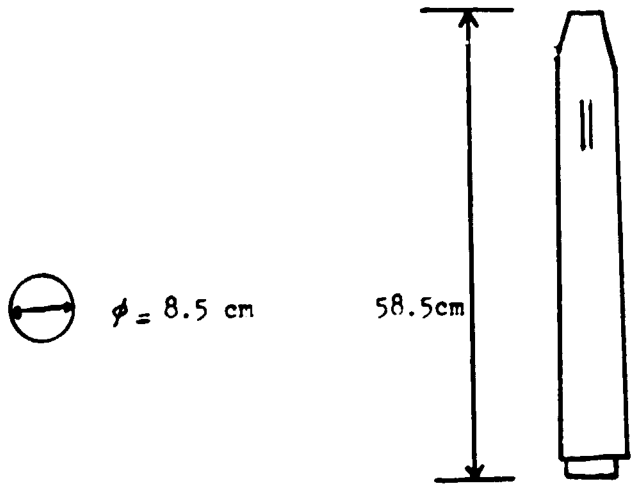
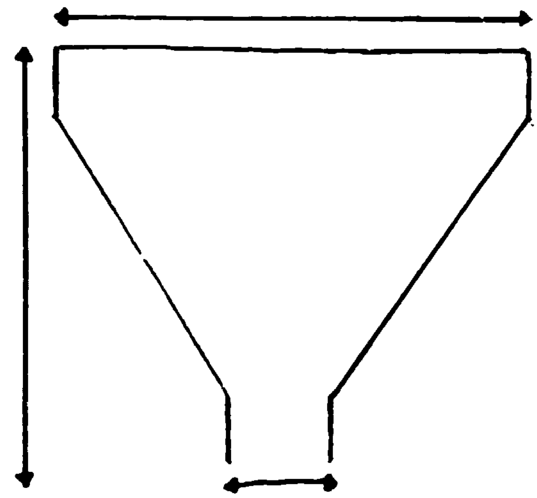
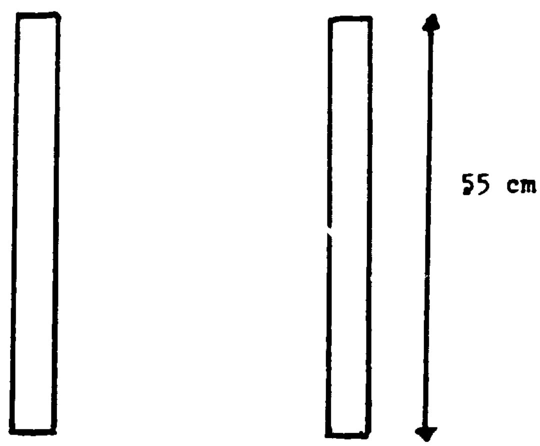


Figure 2.3 Shaft



Hopper



Hopper holding plates

Figure 2.4 Hopper

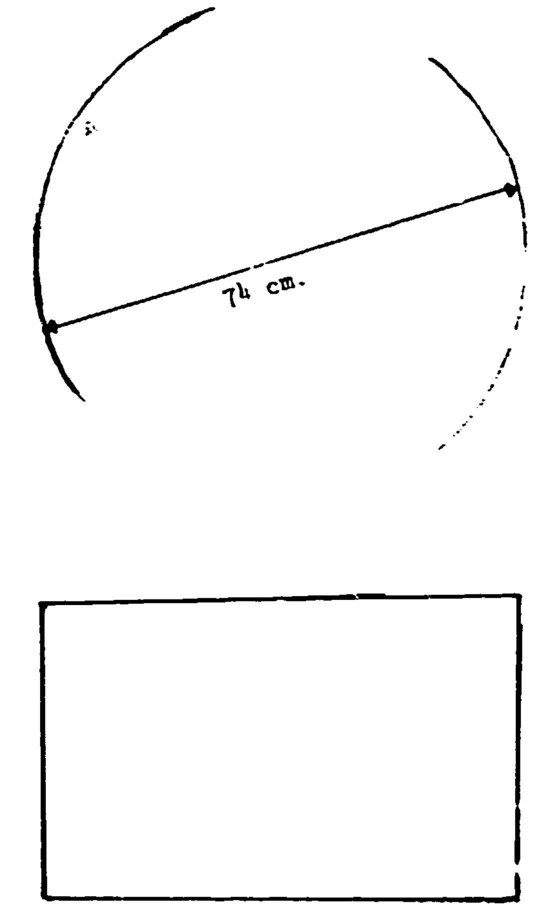


Figure 2.5 Seen from botton
(Lower facing)

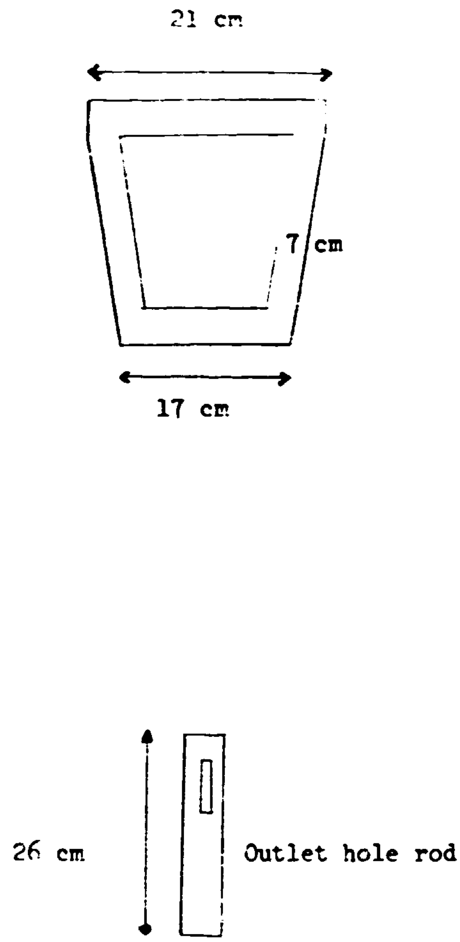


Figure 2.6 Flour outlet

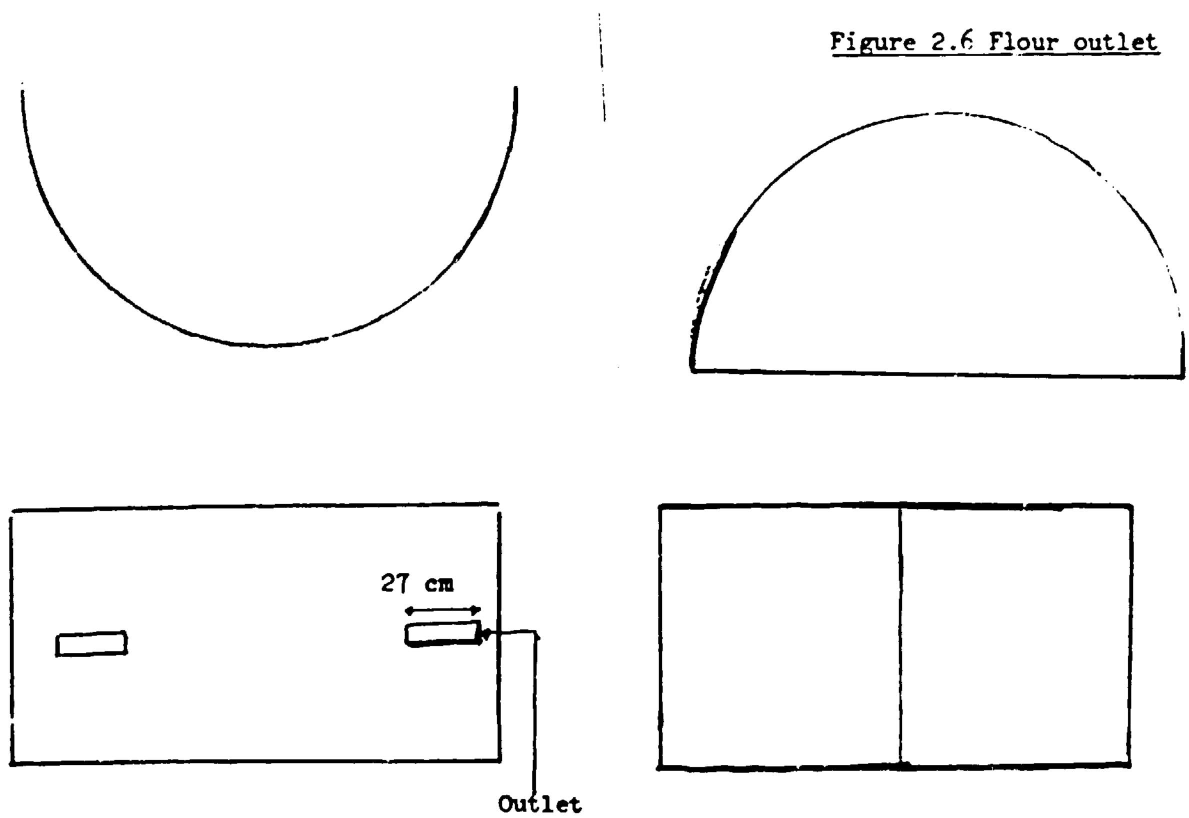


Figure 2.7 Flour outlets

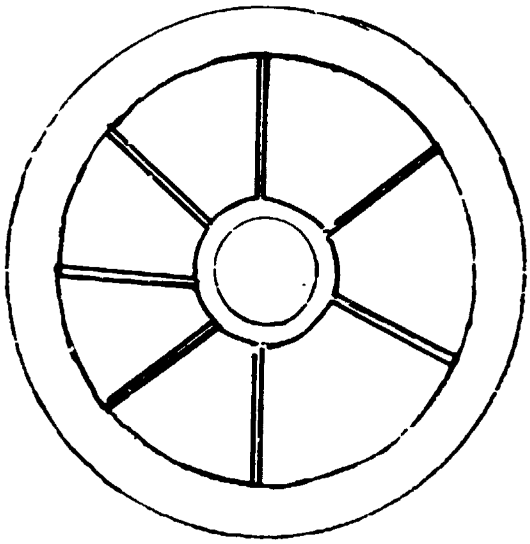


Figure 2.8 Stone wheel

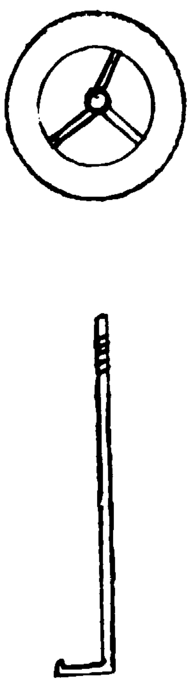


Figure 2.9 Tensioner and spring

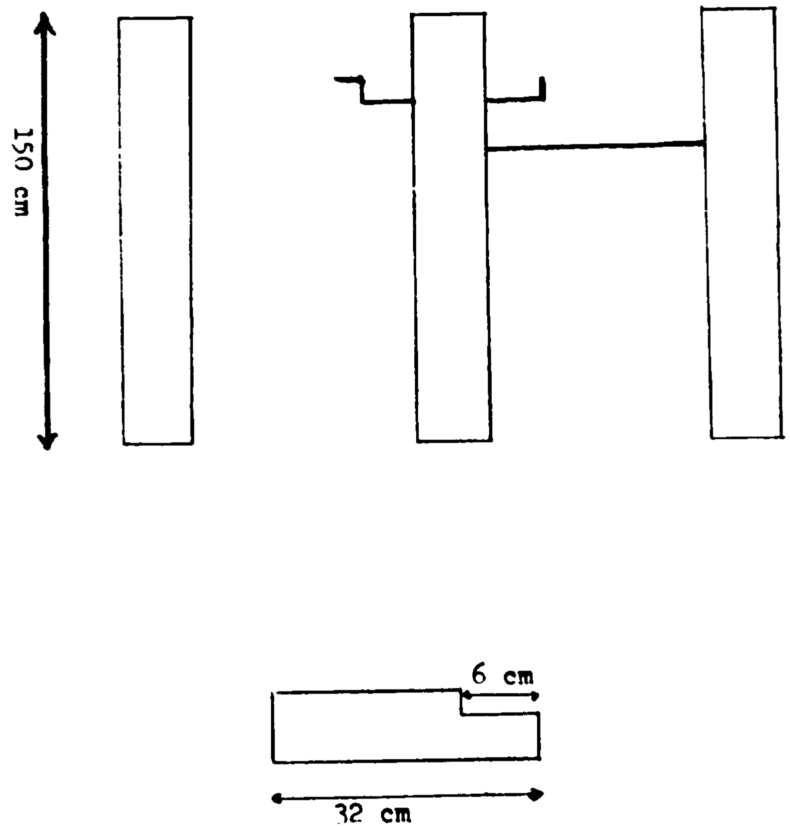


Figure 2.10 Supporting stand

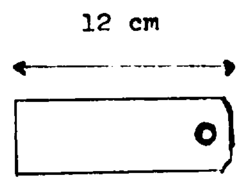


Figure 2.11 Stone fixing plate

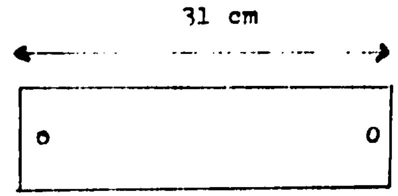


Figure 2.12 Guide