TECHNICAL ADAPTATION: BRET WOOD-CONSERVING, METAL STOVES

Prepared by:

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PREFACE

The Botswana Renewable Energy Technology (BRET) project is jointly funded by the Government of Botswana (GOB) and the U.S. Agency for International Development (AID). The BRET project is a part of the Ministry of Mineral Resources and Water Affairs (MMRWA). Technical assistance and project management are being provided by Associates in Rural Development, Inc. (ARD), of Burlington, Vermont, under AID contract number 633-0209-C-00-1024-00.

This report is based on the work of ARD fabrication and production engineering specialist Eric Brunet. Mr. Brunet spent seven months in Botswana with the BRET project, working closely with local tinsmiths, on the design, adaptation and fabrication of various versions of wood-conserving metal cookstoves, from October 1983 through April 1984.

Dr. John Ashworth, ARD senior associate, shared in the effort to produce this report as a result of his work with Mr. Brunet and other BRET consultants and staff, during an economic consultancy in Botswana in January 1984.

Illustrations and stove plans contained in this report are by Eric Brunet.

Two other technical reports resulted from Mr. Brunet's work during his consultancy. "Production Training for BRET Metal Stoves" covers the training methods used with the tinsmiths of Botswana. "BRET Metal Stove Production Guide for 'B' and 'Delta 3' Stoves" provides a detailed description of how a metal stove is put together, covering all the steps from production of templates to embossing the BRET logo on the outside wall of the stove. These two reports are available from the BRET project.

Work Undertaken

The initial scope of work outlined for this consultancy called for assistance in the final development of sheet metal cookstoves and in sorting out the earthen stove issue by performing the following tasks:

- to review and evaluate stove work and testing to date, both metal and mud stoves;
- to modify design and conduct retesting, if modifications in stove design seem warranted;
- to develop a metal stove market-testing and dissemination program; play a major role in directing and carrying it out; supervise and train project personnel to continue the training process; work with other established training centers in Botswana, where possible; and to incorporate the production of sheet metal stoves;

- to develop a system for social, technical and energy evaluation of stove work;
- to work with BRET staff on all aspects of this effort;
- to provide a draft of a final, written report for BRET staff prior to departure; and
- to provide a final draft of the above report to ARD/ Burlington immediately upon return to the United States.

For the sake of clarity, this set of reports relates only to the work performed with metal stoves. Another set of reports covering construction, testing and training with earthen stoves is being prepared by Carmen Penty Brunet, who contributed time and effort on the mud stove development.

Accomplishments

During this seven-month consultancy, the following tasks were accomplished:

- review and reprinting of fill-in forms for water boiling tests;
- revision of follow-up forms for users of metal stoves;
- collection of feedback from other development organizations, such as PFP, RIO, BEDU;
- production of six prototype metal stoves of models "B" and "Delta" series;
- preparation of an initial three different set of templates;
- training of 11 producers in making a total of 125 metal stoves (May 1984);
- production of 10 wire BRET logos for metal stove identification;
- design of a BRET logo for stationery, vehicles and T-shirts;
- draft of a metal-stove user leaflet;
- draft of a metal-stove publicity leaflet;
- completion of four metal-stove workshops;
- completion of nine separate water-boiling tests on metal stoves and assisting in BRET water-boiling tests with 12 local cooks;

- participation in the BRET passive solar housing workshop, (metal and earthen cookstove update);
- production of plans for all the stoves tested; and
- production of sketches of the various steps needed to make BRET metal stoves.

I. . INTRODUCTION

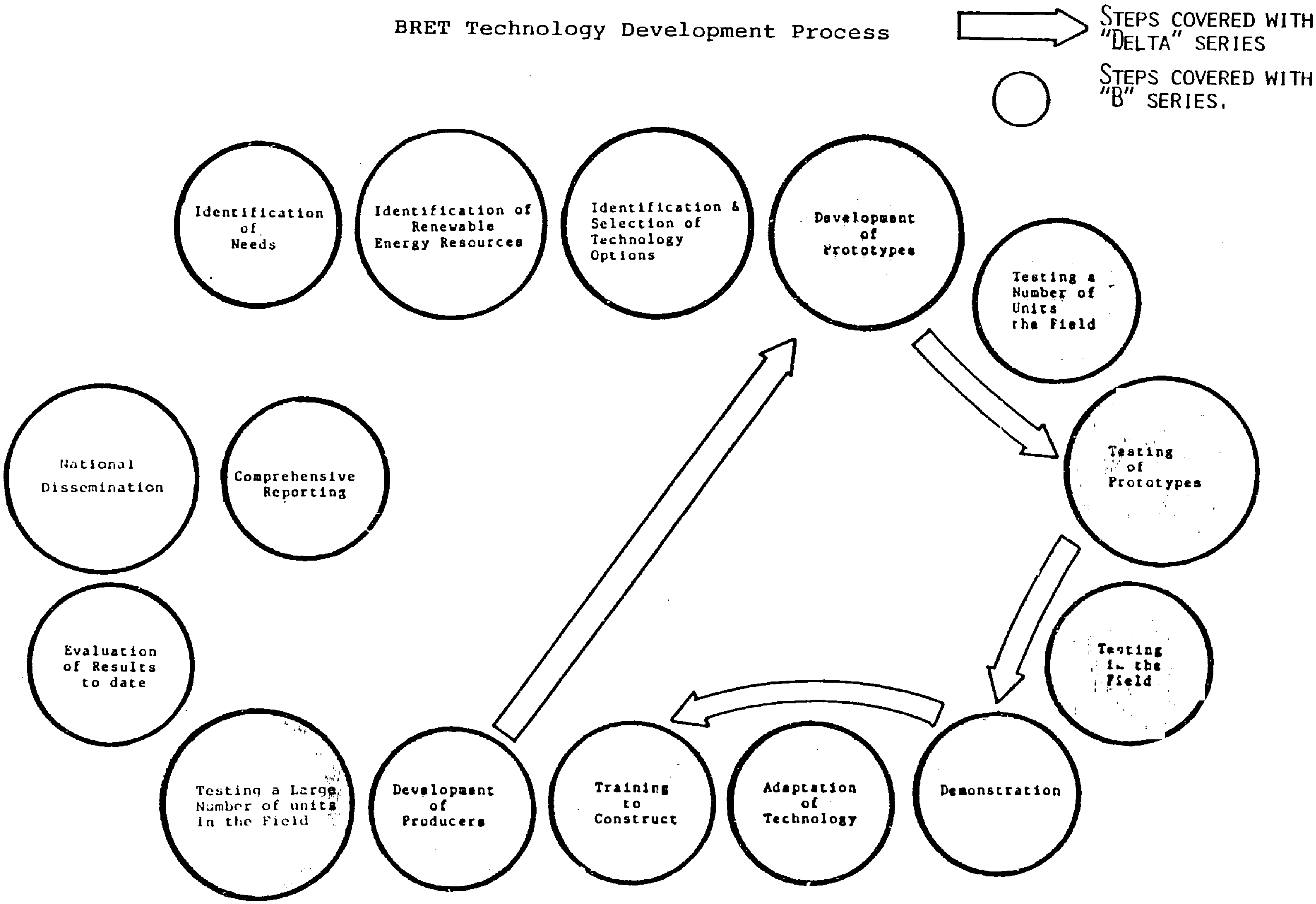
Scarcity and high cost of fuel wood is a difficulty confronting a number of rural and urban Batswana households and the problem is not going to be solved in the near future by reforestation programs only.

Comparatively speaking, wood is cheaper than imported fuels, such as bottled gas and paraffin, but it is inefficiently burned even when used with a pot tripod, commonly found in Batswana households.

For the first six months of 1983, the Botswana Renewable Energy Technology (BRET) project concentrated on developing a prototype metal wood-burning stove that has shown significant fuel economy in all standard tests performed on it. Its general acceptance by field-test users has prompted BRET staff to expand the scope of their activities with this technology so that it reaches the widespread dissemination stage. (See Table 1). This phase of the project, described in this report, starts at the technology adaptation stage and follows through the product's development and the training of fabricators. Attemps have been made to diversify the strategies for dissemination so that producers at different technical levels (major manufacturers as well as small-scale entrepreneurs) are all included.

Table 1.

BRET Technology Development Process



II. THE STARTING POINT

There were three initial prototypes developed by the ARD stove consultants, (see Geller et al, 1983). The third design, the Model 3, was selected for further adaptation work. It was designed to accommodate the cast-iron, three-legged pot, sizes #1, #2 and #3. It is a one-piece cylinder cut from 0.5mm galvanized sheet metal with a diameter of 32cm. This allows free space between the stove wall and the pot's outer lip of 6cm with pot size #1, 3.5cm with #2 and 2cm with #3. The 2cm rather than a 1.5 or 1.0cm gap allows for the considerable variations found in cooking pots in Botswana. The outside wall is fitted with a hinged door, perforated with six 12mm holes. A latch and lock permit closing the stove firebox completely.

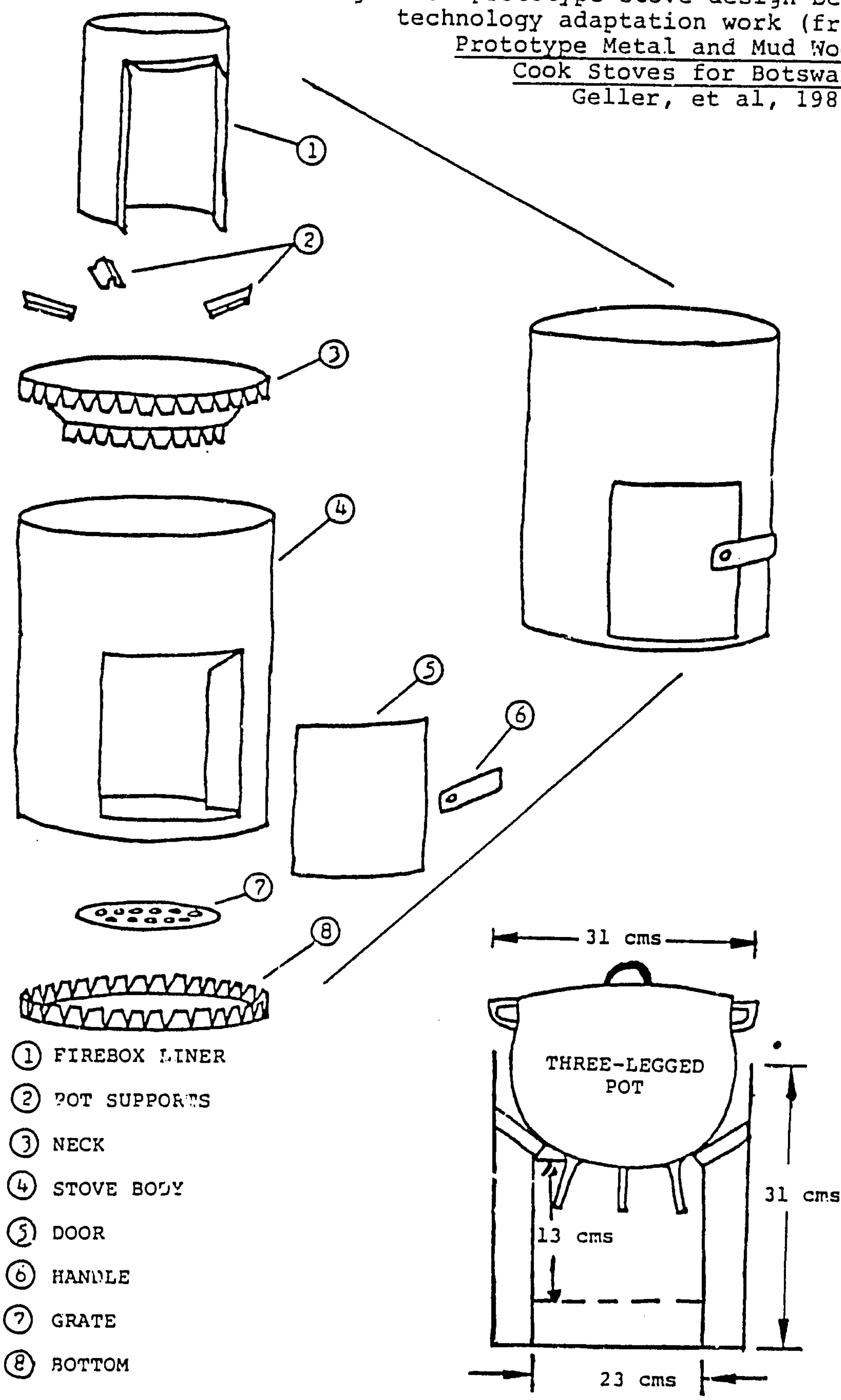
An inside wall of 0.8mm galvanized sheet metal was inserted inside the stove to create an insulating airspace of 4cm. A section of it was cut to connect the outside wall. Metal screws were used to keep the outside-wall door fold attached to the inside wall, and a top ring of metal (0.8mm) was riveted to the inside wall. Sheet metal screws secured the assembly to the outside wall. Three pot pads, made from 0.5 mm were riveted to the top ring to allow hot gas and smoke to escape around the pot. The bottom plate was a disk of metal (0.8mm) with folded edges, fitted and attached with five sheet metal screws to the outside wall. A grate cut from 1.6 metal was perforated with 25 1cm holes. Three protruding flaps were bent to act as supports.

The Model 3 was handed over to a tinsmith for design adaptation and further testing. About 30 copies were made and used for controlled cooking purposes.

In the prototype Model 3, the rate at which the metal stove inside wall warmed up was rather fast, after which the total heat absorbed and transmitted to the pot decreased to a constant, steady-state value (Baldwin, 1984). There were two questions to be addressed in the stove wall design: safety and thermal efficiency. Filling the stove double wall with really nonconductive material, such as fibreglass or vermiculite, offered safety aspects for children and a slight efficiency gain, but drove up the price of the stove and made it much heavier. Leaving a dead-air space, instead, saved greatly on labor costs and weight.

Our experience with the stove is that the double wall prevents a direct contact of fire and coals with the outside wall, thus reducing to some extent the conduction. The wall is never hot enough to produce a serious burn.

Diagram of prototype stove design before technology adaptation work (from Prototype Metal and Mud Wood-Burning Cook Stoves for Botswana, Howard Geller, et al, 1983, p. 20).



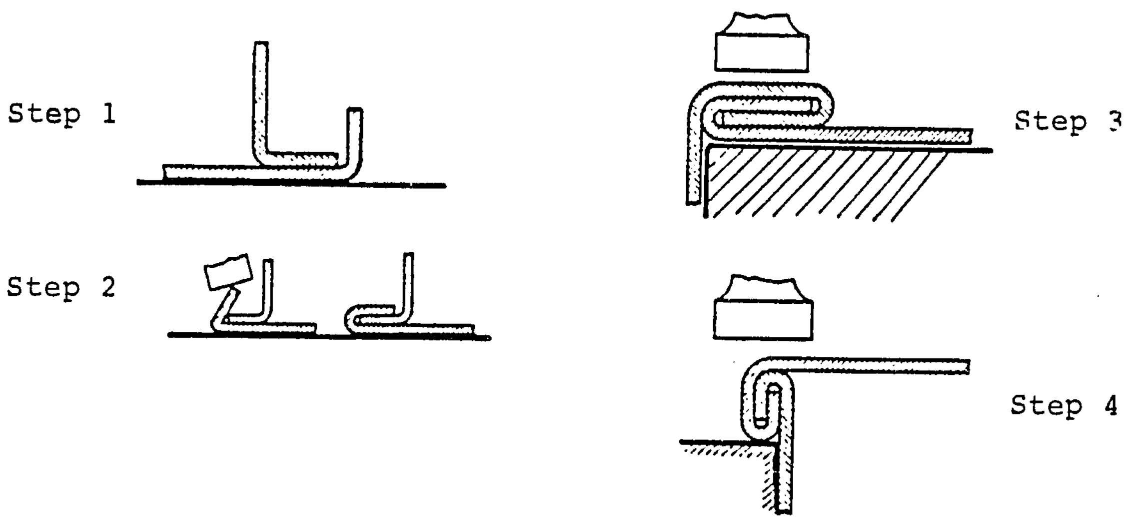
drawing by Glenn Burket

III. FIRST STEP TO A PRODUCTION MODEL METAL STOVE

A. The BRET "B" metal wood-conserving stove

Accurate measurements were taken from several of the Model 3 prototypes and compared with the sketches available. One sample was completely flattened to see what measurement method was used. Our first impression was that the metal stove Model 3 was not close enough to the construction techniques used by the Mazezuru on their common buckets and wash basins. Also we noticed that the Mazezuru use templates or patterns in their work.

With this knowledge, a set of design criteria was drafted, keeping the general layout of the Model 3. To permit a one-piece construction, a knocked-up seam technique was adopted for fastening the outside wall to the bottom plate. This proven method is commonly used by the Mazezuru for all their products. It makes the use of sheet metal screws unnecessary, which was a valuable alternative as screw drivers are not commonly owned in Botswana.



Forming a knocked-up seam.

The stove would be made using a tried and proven set of templates to provide the tinsmith with some degree of precision and assume an interchangeability of the components. It would facilitate large "runs" of metal stoves, cutting down the time needed for careful measurement. For example, the number of holes in the grate would be the same for each stove. Also, by providing a uniform appearance, the stove could have the additional market advantage of a professional finish.

Tracing templates.

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To ensure maximum life, as people frequently ask how long the stove will last, and to keep the price to a minimum, materials would be selected to withstand fire and coals. Three components -- the grate, inside wall and pot pads -- were redesigned to ensure ease of fabrication, replaceability when burned out and low cost.

The grate is a disk of steel, cut from 1.6mm hot rolled steel, where the edges are bent up to prevent warpage, (see the exploded view of "B" series).

The inside wall has a flanged bottom to fit squarely on the bottom of the stove. The door sides are folded in a way to interlock with the outside wall. This means that, in case of failure, it can be slipped out easily and a new liner inserted.

Cutting and trimming sheet metal parts (left).

Cutting out the grate with a chisel (right).

Punching holes in the grate (left).

Marking with edge gauge (right).

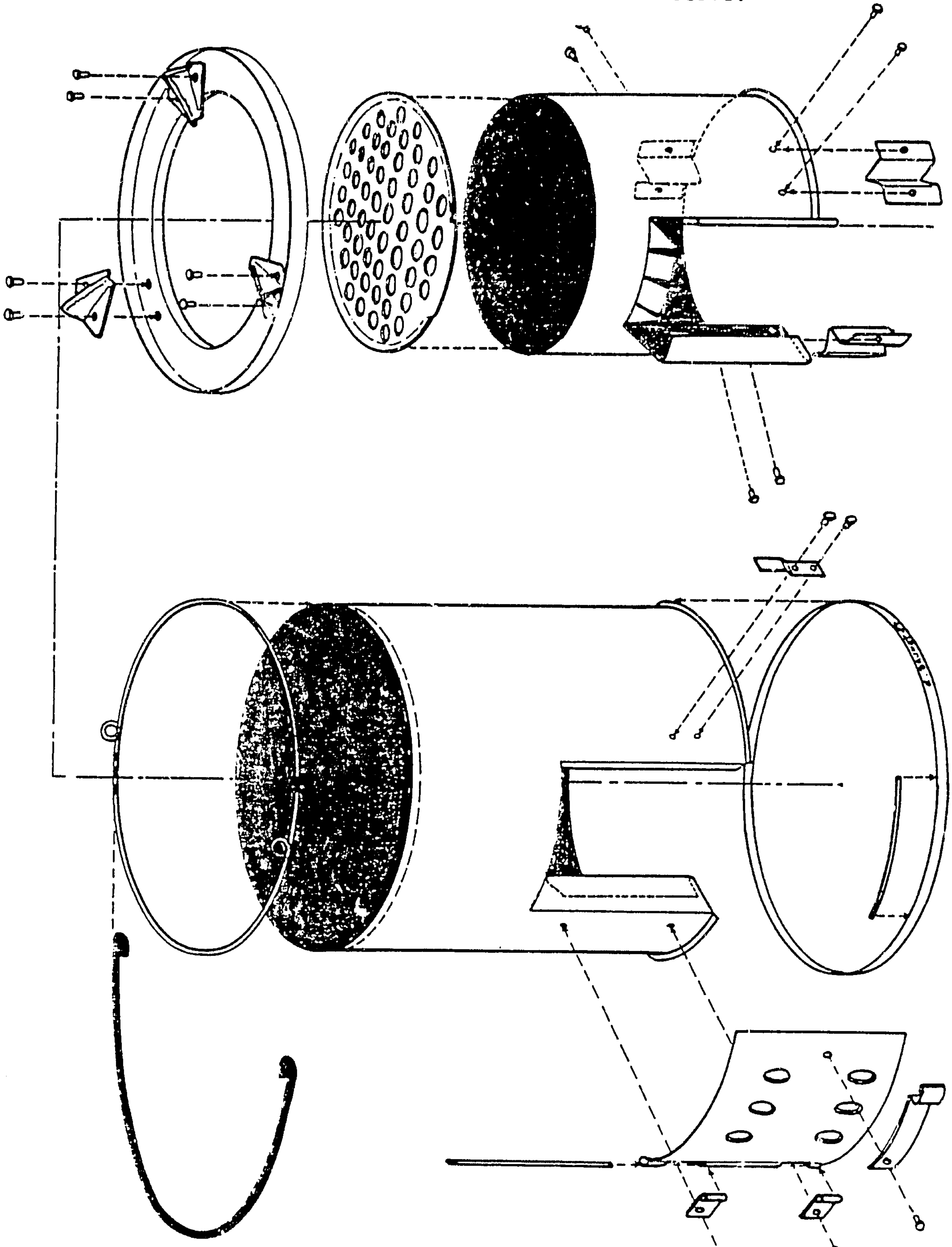
The three grate supports are made from the same material (preferably 1mm gauge) and should not be bothered by high heat.

The pot pads got most of our attention since they must support a heavy weight while subjected to flames. Four models were tested, combining ease of fabrication and durability. An 0.8mm edge-folded pad was maintained, while a 1.6mm part, cut from the grate sheet metal leftovers, was suggested. It was noted during a heavy firing of a sample Model 3 stove that the edges of the pot pad were bending and burning away. Using the folded 0.8mm gauge pot pad would provide three times the original thickness and, therefore, last much longer.

Finally, the pot pads were riveted to a top ring that was friction fitted in the outside wall. The inside edge of the top ring was bent in to effectively cap the inside wall on which most of the pot weight rested. One pot pad is always centered in the middle of the door so that two legs of the cast-iron pot will always straddle the door. This makes stoking wood in the firebox much easier. Another reason for the development of the friction-fitted top ring is the possibility of removing it and packing the the airspace with insulating material. (This notion remains from tests performed to compare prototypes of Model 2, which had a 2.5cm mud/vermiculite insulated wall.)

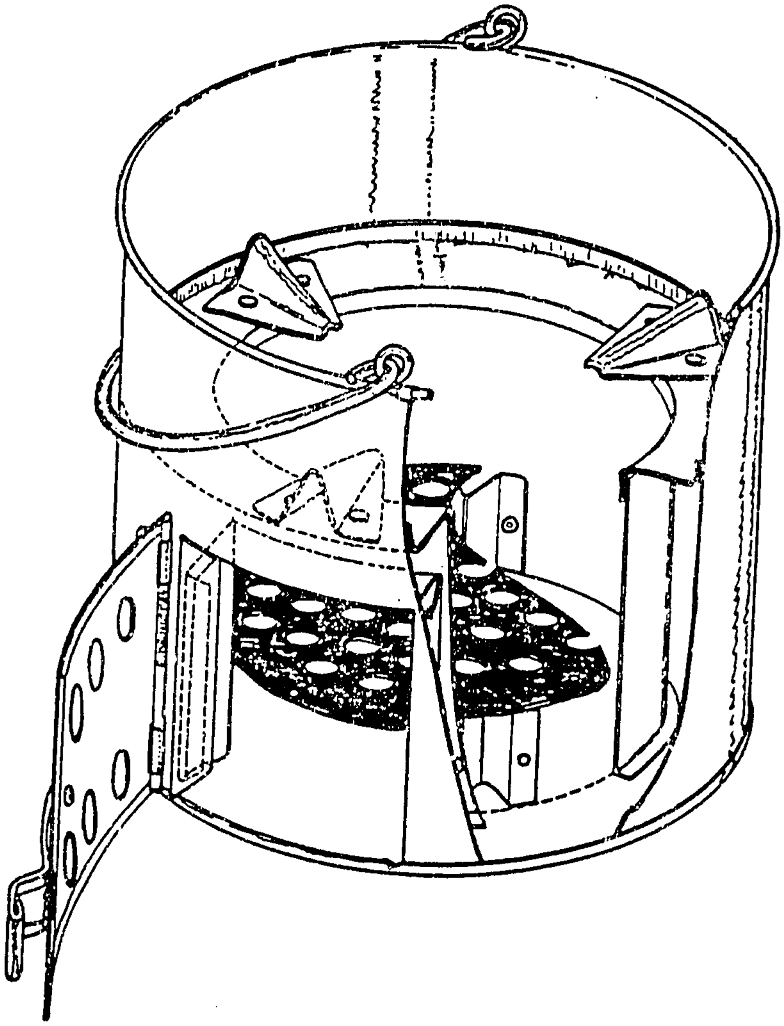
Forming the top ring.

Exploded view of BRET "B" series stove.



drawing by Eric Brunet

For the sake of simplicity and cost, the airspace was retained as the best solution for the "B" model, even though the insulating value of common materials, such as fibreglass, were all seven times greater than air alone. The idea of leaving the customer the option of stuffing some kind of clay in between the walls for insulation still remains, but is probably unrealistic.



Cutaway view of BRET "B" metal stove.

B. Attention to Details

The "B" stove was fitted with a door designed to lengthen the simmering time, especially in windy outdoor conditions. To be used effectively, the door was hinged, and the latch and lock were substantially larger than on previous stoves, with smoothed edges for safety to the user.

The original position of the handle loop, made of 6mm steel, was moved from the top to the side. This allows for picking up the stove during cooking without coming in contact with hot gases. In this way, the user can easily relocate the stove downwind or under shelter while it is hot.

A braii grill comes as a standard accessory with the "B" stove, permitting the owner to use the remaining embers left from cooking to grill meats.

C. Attention to Material Use

With the introduction of templates, it became possible to follow strict rules in the use of metal sheets, which normally come in standard 4'x8' (121cm x 131cm) sheets. The outside wall, for example, was trimmed 1.5cm in length to fit exactly eight times onto one sheet, with door and lock parts.

The grate, trimmed of its three-flap support in Model 3, now fits 50 times onto one sheet. The inside wall, adjusted to 20cm in length, fits six times in the sheet width. The braii grill, cut from expanded metal, can be replicated 31 times.

More difficult is the efficient use of circular parts, such as the bottom plate and top ring. (A parts layout guide for the "B" stove is included in the BRET Metal Stove Production Guide.) Although small parts can always be cut from waste materials, such as grate supports, grill handles, etc., there are limitations to this practice.

D. Attention to the Finish and Identification

Everyone who compared the Model 3 prototypes and the "B" stove agreed that the latter has a professional appearance -- holes in the door and grate are straight and even, the top ring is truly circular, there is no warpage at the inside or outside wall overlap, as was common with the screw-fastened Model 3. The stove bottom is an integral part of the stove body. Also the "bucket" look has been somewhat lessened by embossing the BRET logo on the front. At the end of each training session, tinsmiths were given an embossing wire, with the agreement that all stoves would be stamped above the door.

E. Development of the Large "B" Stove

With the distribution of the first batch of Model 3 stoves, a follow-up user sheet was handed out to get back information on stove performance. Some answers confirmed that users wanted the changes incorporated into the "B" stove, but also wanted a larger stove so as not to have to repeat cooking operations to prepare one family meal.

BRET's participation in the general meeting of the Rural Industrial Officers (RICs) in November 1983 brought out a number of critical comments on the "B" stove and its inability to accommodate large pots. Observations made during lunch-time cooking at industrial sites and schools confirmed that a larger stove, accommodating up to a size #6 pot, would be welcomed. In terms of a marketing strategy, giving the customer a choice of two prices is always advantageous. Hence, the development of the "Super B" model.

The "Super B" stove is basically identical to the "B", except that it will accommodate pots ranging in size from #1 to #6. (Fuel efficiency, however, directly relates to pot size, with large units having a smaller gap between stove well and pot and, therefore, better heat transfer between hot gasses and the pot itself.)

The "Super B" stove was tested during water-boiling test sessions in March 1984, as shown by table 4, section IV. (A set of plans for the "Super B" stove appears in the appendix.)

F. Sale Price

A retail price was established initially at P15.00 (pula) for the "B" stove, with the fabricator getting half that amount for labor.

IV. FURTHER ADAPTATION OF METAL STOVES

A. Creation of the Delta Series

Three training sessions with potential producers showed certain limitations of the "B" series stoves. Although more easily assembled and much more durable than the early laboratory prototypes (Models 1 through 3), the "B" series had several problems that prevented the serious interest of potential producers. Among its problems was the large number of parts and, hence, the time involved in assembling the stove, which meant that one and a half person-days of labor were required per stove.

Workshop participants complained that the allowance for labor cost should be increased two-fold, since government industrial employees earn 7.25 pula per day or more. (This figure should be viewed only as a guideline since the informal sector is not governed by this scale.) Tinsmiths pointed to this alternative employment opportunity as an indication that the production of a half to three-quarters of a stove per person-day of work does not provide a sufficient incentive to produce with a retail price set at P15.00.

This problem increased with the larger, "Super B" stove, as the material requirements and labor costs to produce one unit were even higher than those of the "B" stove, owing to its larger dimensions and heavier materials. Therefore, it was decided to develop an alternative design to the "Super B" that would meet a number of goals. These were:

- to reduce the cost of materials;
- to reduce the time needed to make a single stove;
- to maintain a heavier gauge metal for the stove wall;
- to improve the pot support method, and
- to provide a unit that can be mass-produced by existing metal-fabricating industries.

After a period of experimentation, a new line of stoves was developed, using an integral pot support tripod that locked into place in the stove instead of the pot support and top ring. The new series was named "delta" because of the triangular shape of the tripod, and the two stoves developed were called the "Delta 3" and the "Delta 6."

B. General Comments

As Table 2 shows, the cost of the "Delta 6" is proportionally

Table 2.

Comparative Material Cost of the BRET Metal Stoves

Material	Cost in Pula "B"	"Super B"	"Delta 3"	"Delta 6"
Grate (1.6mm)	.80	1.25	1.73 (includes bottom)	2.22
Top ring (0.8mm)	1.13	1.44	none	none
Bottom plate (0.8mm)	1.15	1.27	none	none
Outside wall	1.93 (0.5 gauge)	2.95 (0.8 gauge)	2.80 (0.8 gauge)	2.92 (0.8 gauge)
Door	included	.12 (0.5 gauge)	included	.12 (0.8 gauge)
Inside wall (0.8mm)	1.45	1.73	1.00	1.11
Rivets	.10	.10	.20	.20
Grill (expanded metal)	.65	1.38	.65	1.38
Grill handle (0.5mm)			.10	.10
.35 wire	.20	.30	.20	.30
.60 hoop handle	.15	.20	.15	.20
Pot support (3) (1cmØ)	none	none	.58	.60
	7.56	10.74	7.41	9.15
without grill	6.91	9.36	6.66	7.67

(these costs include wasted material)

Examples of 1984 prices in pula:

Six-meter 1cm reinforcing rod	3.10
Six-meter 6cm reinforcing rod	1.27
(50kg) wire .35 gals.	50.00
grill exp. metal	25.00
black 1.6 sheet	40.00
0.5 galvanized sheet	16.00
0.8 galvanized sheet	23.50

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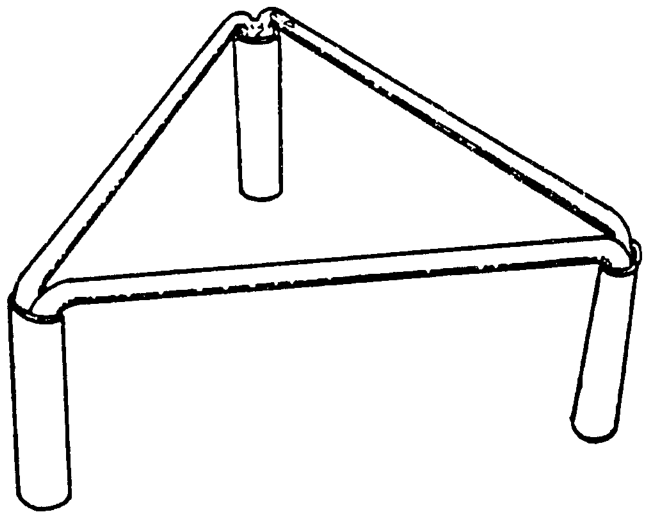
lower than the "Super B," while the "Delta 3" is roughly the same cost as the "B" model. The latter is due to the cost of the outside wall being made from a heavier gauge (0.8mm) metal. This is necessary for riveting 1.6mm pot support straps to the outside wall. A thinner gauge would be less durable. (0.8mm is still easy to cut with standard snips, but won't tear, as will a 0.5mm gauge.)

Two of the more difficult parts to produce were eliminated--the top ring and the bottom plate. This meant an alternative to the pot pad had to be superior. Observation of stove use showed that most people use a tripod 10mm to 12mm in diameter. These are generally welded and fitted into sections of tubing. In the case of the "Delta" system, welding had to be avoided to permit replacement of individual bars or straightening, if needed. The pot support tripod of the "Delta" offered greater durability and stability than the previous "B" pot pads. Also, flat pans were less likely to get knocked over. Manufacturing techniques were also faster as there was no hole punching, hand pushing or adjusting to be done. (The right-angle bending method is described in the BRET Metal Stove Production Guide.)



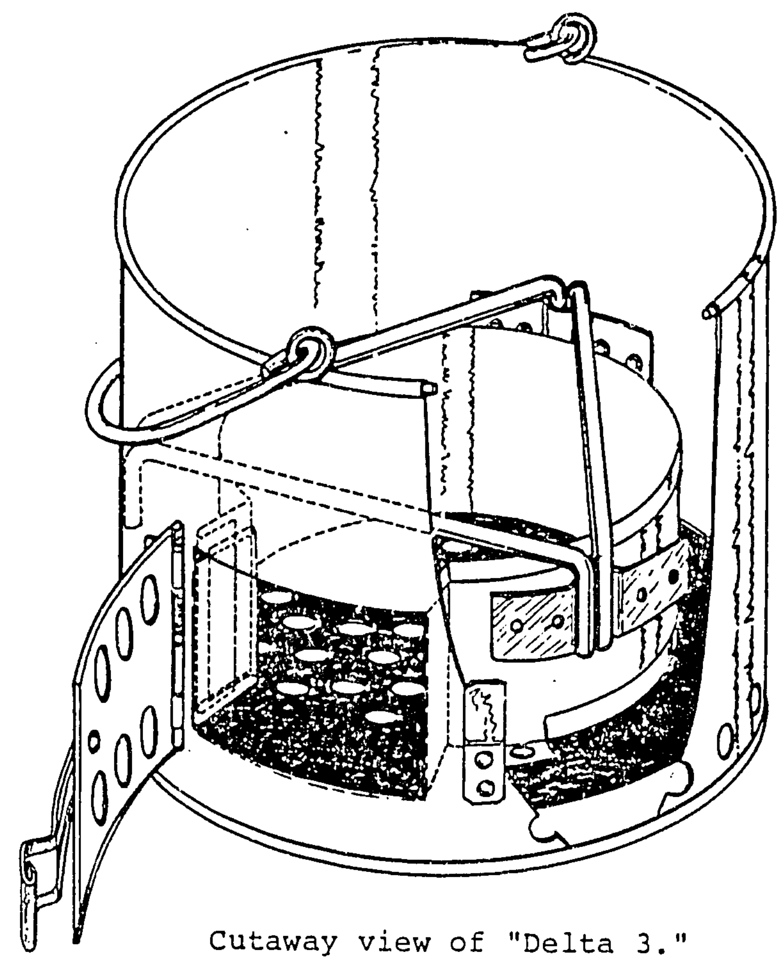
A typical tripod used in Botswana.

The inside wall is simple to make as there are no grooved seams to make. By extending from the grate floor to the tripod bars, the inside wall effectively shields the outside wall from the fire when a flat-bottom, aluminum pan is used. The hot gases and lames are squeezed into the 1cm-high ring, regardless of the size of the pan, providing that its diameter is less than that of the inside wall. Also. the fold-over bottom edge protects the metal in contact with hot coals.

Three rivets fastened the tabs of the inside wall to the grate, and the same double-fold, interlocking techniques used on the "B" series was adopted for joining both the inside and outside walls.

Having no bottom plate to the stove at first appeared inconvenient -- ashes would spill onto the surface where the stove stood, requiring some form of sheet metal floor protector during indoor cooking. On the other hand, some benefits seemed possible too. The door was made shorter so that it did not scrape the ground on opening. Punched holes at the bottom of the outside wall replaced the air intake which, previously, came from the bottom of the door under the grate. In all tests, these changes proved satisfactory.

The general appearance of the "Delta" stove remained the same. A dozen people asked to comment on on the new features were strongly in favor of the "Delta" tripod. Also important were the comments of producers, who had already attended the training workshop for the "B" stove and had made stoves for BRET. All said the new model would increase production from two to three stoves per worker per day, providing they had a bending jib. They pointed out that gauges of sheet metal had been reduced to only two (0.8cm and 1.6cm), and that the two most difficult parts to cut and fit had been eliminated altogether. This, and the substantial drop in material costs for the "Delta 6," would make this model very competitive.



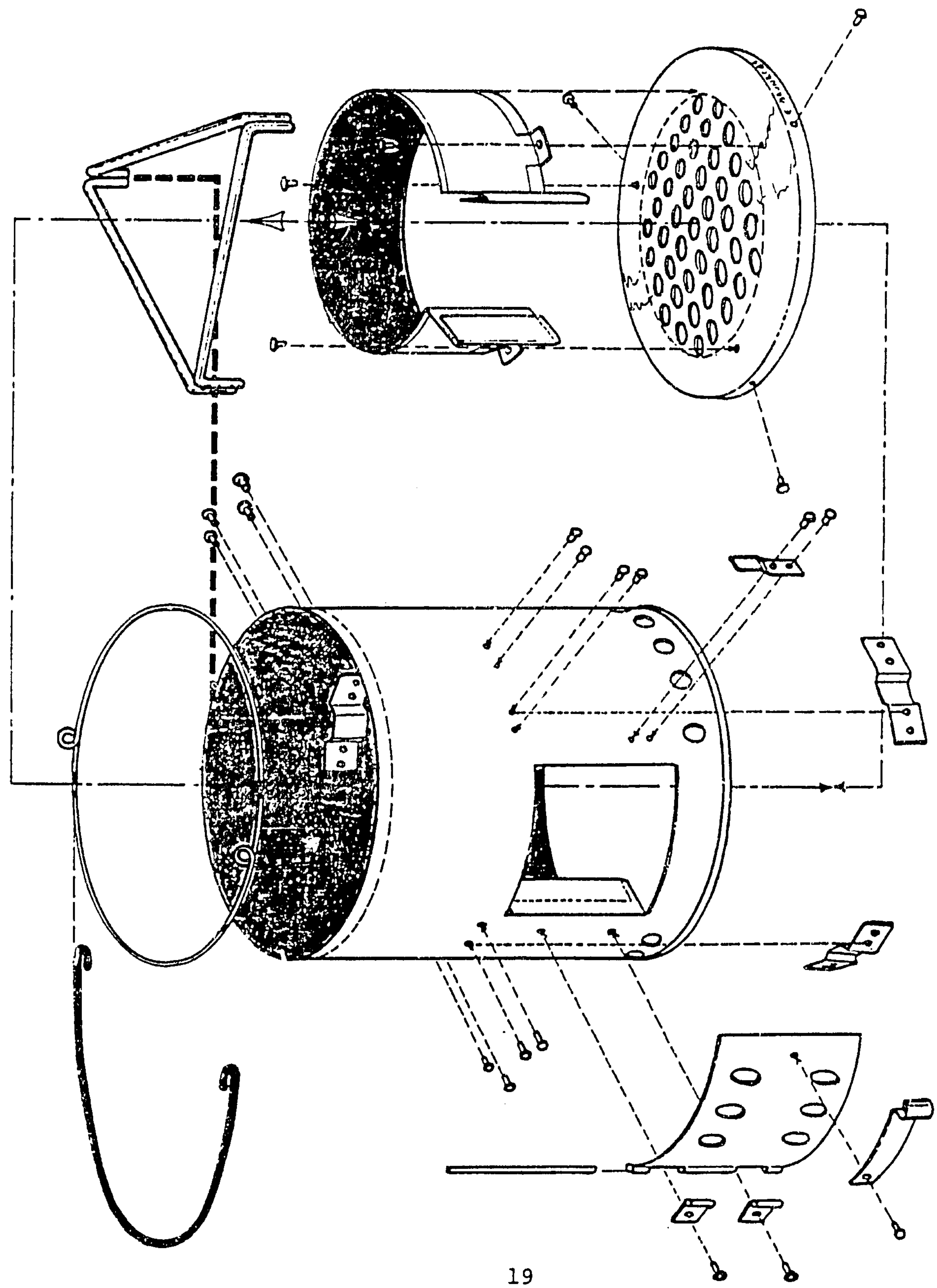
Cutaway view of "Delta 3."

C. Unresolved Issues

Mass producing the small, "Delta 3" metal stove would require some changes in the stove as built by tinsmiths without power tools:

- tin rivets would be eliminated and replaced by either spot welds or pop rivets for the door hinges and fastening the grate to the outside wall;
- a rolling machine would be used to make the cylindrical sections, which could mean that a heavier gauge (1.6mm) mental could be used for the inside wall without much increase in cost;
- a hole punching machine would provide the proper sized holes for the grate, which is no so easily done by hand;
- a rotary shearing machine and edge creaser would take care of the blanks produced by the drop shear;
- some kind of die would have to be produced to punch out the door "H" cut;
- embossing the BRET logo would be performed by pneumatic press, which could also be used for making the bottom air holes; and
- the pot-support triangle would be produced by assembling three L-shaped rods (12mm), welded together to form a tripod, and then welded to the grate with spot welds or pop rivets located right under the bearing rod to ensure that the grate assembly is reliable under heavy loads.

Exploded view of "Delta" series metal stove.



drawing by Eric Brunet

V. WATER-BOILING TEST RESULTS

A. Comparison of "Delta 6" to Early BRET Metal Stove

The authors conducted a series of water-boiling tests to rate the new "Delta" line. Cast iron, three-legged pots do vary from one manufacturer to another, so the idea of matching pot to stove was simultaneously investigated. Stoves of two diameters (38cm and 36cm) were tested with the same size pot, giving a wall-to-pot clearance of 2cm and 1cm, respectively. One technical detail we noted was the difficulty of producing a stove on which a pot centers perfectly. There are some implications regarding ideal heat transfer, at least for the largest size matching pot.

Even thought the stove wall may be perfectly cylindrical, when one of the pot supports is placed incorrectly, the pot will be off center. This creates a crescent-shape flue effect rather than the idea annular exhaust. The clue that a pot is off center or that combustion is incomplete is a deposit of soot in the area of close pot contact with the stove wall. The water-boiling test table (Table 3) indicates that matching pot to stove improves the convection of hot gases to the pot.

The Equivalent Dry Wood Consumption (EDWC) drops down 1.5g to 1.29g. The time it takes for water to reach a boil also decreases (39.5 minutes less 15 minutes of steady boil is 24.5 minutes--not a bad figure for 8.8 liters of water).

Nevertheless, the number of tests performed are too few to be 100 percent sure that these figures will result all the time. The skill of the operator to judge how to build the fire, at what point to close the door, how to estimate the appropriate quantity of wood to maintain a simmering pot have to be taken into account. However, an understanding of how one can reduce the consumption of firewood using these stoves leads to progress.

Another observation confirms that fact that there is a relationship between pot size and efficiency: As the pot becomes larger, so does the percentage of heat utilization. This is true of both open and shielded fires.

B. Test Results Comparing BRET "B" Stoves to Open-Fire Cooking

The water-boiling test method follows the provisional international cookstove testing standards (VITA, 1982). The test is carried out in two parts: a "high-power" phase and a "low-power" phase. The high-power phase simulates short, high-output cooking tasks, such as frying, rapid water heating or vigorous boiling. The low-power phase simulates longer, low-heat output cooking tasks, such as simmering.

Table 3.

WATER-BOILING TEST AT BRET MARCH 1984

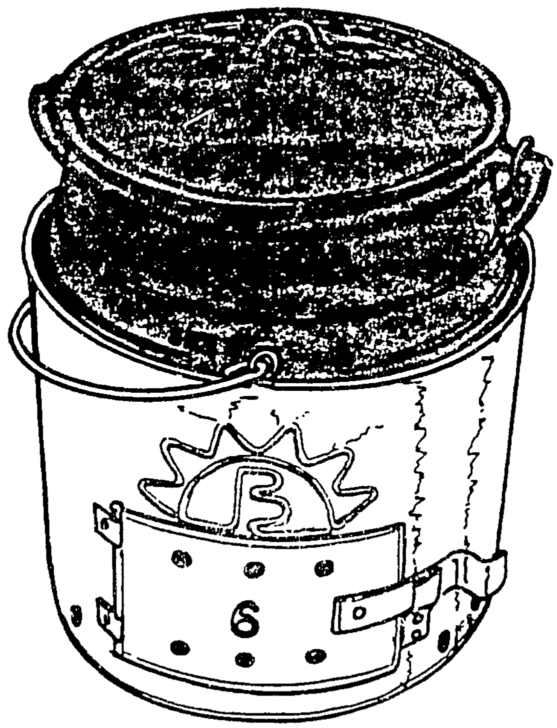
(Partial list)

Stove type	Pot size	Time for HPP	EDWC	SSC HPP	SSC-LPP	PHU	Power Ration	PHU	
Openfire	1	36	1.24	4.84	7.91	6.77	6.39	6.27	
	1	30	1.01	1.74	1.62	9.05	1.96	7.84	
	1	39	.992	3.74	1.78	6.78	2.95	5.71	
	1	33	1.00	2.59	2.53	6.89	3.06	6.28	
	1	26	1.69	2.59	1.52	7.71	1.75	6.18	
	3	33	1.51	2.90	2.28	8.56	4.24	7.58	one-
	3	33	1.50	2.98	1.33	10.40	3.40	8.44	time
	3	48	1.60	3.24	2.47	8.47	1.12	7.18	users
	3	43	1.68	3.40	1.52	9.23	2.13	7.44	
	3	36	1.92	4.86	1.52	8.31	2.38	6.77	
STOVETYPE OPENFIRE	6	60	2.80	2.50	2.60	8.77	1.34	6.83	
	6	51	1.77	2.08	1.39	13.2	2.33	10.52	
	6	52	2.49	5.34	3.47	7.65	2.65	6.93	
	6	98	2.84	4.60	1.43	14.2	2.51	12.11	
STOVE TYPE "B"	3	34	1.29	1.46	.842	15.08	3.84	14.25	
	3	27	1.14	1.20	.56	20.54	3.13	17.93	
	3	36	1.34	1.59	1.02	13.80	3.18	12.35	
	3	26	1.35	0.60	2.5	17.07	2.69	15.89	
	3	33	0.95	.655	1.23	15.42	4.92	14.11	
STOVE TYPE SUPER "B"	6	51	2.35	2.04	0.45	19.22	1.34	16.44	one-
	6	40	1.69	1.09	0.42	24.84	2.09	19.67	time
	6	48	2.49	1.71	0.69	16.7	2.65	14.25	users
	6	35	1.76	1.21	.68	19.44	3.34	16.81	
"Delta 6"	6	47	1.44	1.30	.76	20.07	3.27	17.03	2cm
	6	59	1.80	1.52	.48	21.42	1.84	15.90	space
	6	34	1.54	1.08	.41	31.67	3.05	27.46	wall pot
	6	42	1.37	.995	.326	30.02	2.92	29.95	1cm space wall
	6	37	1.21	1.02	.388	27.51	4.76	23.87	pot

In preparation for the test, notes are taken on the location, weather conditions, pot(s) used, person conducting the test, and any other information that could affect the results. At the start of the test, pots are filled two-thirds full with tap water. Initial measurements are taken of the weight and temperature of the water in each pot, and the weight of wood set aside for use during the test, including kindling. A piece of cardboard is used to ignite the fire, and timing begins when the fire is established and pots are put on the stove, usually one to two minutes after lighting.

During the high-power phase, the water in the main pot is brought to a boil as quickly as possible. Fuel is added to the fire as needed. The water temperature is measured and recorded every three minutes until boiling is reached, and the fuel changes are noted. This is useful for maintaining a high fire and evaluating the ease of operation. When boiling begins, a high fire and a rolling boil are maintained for an additional 15 minutes to complete the high-power phase.

When the high-power phase is completed, the time is noted and intermediate measurements are taken. These consist of the weight and temperature of water in each pot, the weight of remaining wood, and the weight of hot charcoal in the stove. Charcoal, wood and pot(s) are then returned to the stove (or open fire), and the low-power phase is begun once the fire is ignited again. The time required for the intermediate measurements and relighting is typically five minutes.



"Delta 6" metal stove with #6 cast-iron pot.

For the low-power phase, the water in the pot on the main opening is kept simmering at a low boil for one hour. The operator attempts to use as little wood as possible. If for some reason the temperature in the main pot drops 5°C below the boiling point, the test is discontinued. After one hour, all the measurements are made again and the test is completed. Data are then fed into the computer, which allows for rechecking all entries either on the screen or printout, further reducing chances for error.

Results of water boiling tests conducted at BRET are presented in Table 3, giving an average for N number of tests. Note that most "cooks" were women invited from Mogoditshane. Their experience as one-time users would improve substantially over time.

VI. DISSEMINATION STRATEGIES

A. Organization and Control of Dissemination

In dissemination, there are a number of people potentially involved:

- parastatal producers,
- informal-sector producers,
- industrial, private-enterprise producers,
- the recipient population,
- the retailer,
- the mass media (information), and
- those who oversee product quality and performance.

This list points out the need for at least one person or team of people to orchestrate production, publicity and sales.

Just what technical skills BRET can contribute and on what level of priority metal stoves should be placed also will influence dissemination and define the relationship of the infrastructure needed to make stove dissemination a national issue. Obviously, the problem of creating a dissemination strategy for the metal stove resides in effective local organization and information distribution.

B. Considerations in Planning Strategies

Four conditions must be satisfied for a person to want to own and use a new stove (Hassrick, 1984):

- She or he must be aware of its existence and of the functions it performs;
- She or he must have access to it;
- She or he must regard the stove as superior to what is currently used or other alternatives available, and
- She or he must regard it as more desirable than other goods or services which would be acquired with the same resources.

The chief purpose of an improved stove is to save wood and money for its owner. The more people owning stoves, the more the Government of Botswana will be able to evaluate the benefits of their introduction to the nation and individual households.

The general distribution of the population and fuelwood in Botswana should dictate priority areas for stove dissemination.

With no precedents or new experience from other African countries, a successful stove program should encompass different strategies to increase the chances for success. BRET already has experienced the "bottom-up" approach (Moris, 1981) by training, successively, two groups during the prototype phase and four groups during the larger production phase.

Two other possible strategies are under scrutiny: the "top-down" approach and the "commercial" approach. The first has a larger component of structured government involvement. The latter is currently being investigated by BRET, after realizing the rather low turnover of the informal sector. In this approach, BRET would advance funds, buying large quantities of stoves to make them visible and accessbile in a relatively short time. At this stage, it is believed that large production will not inhibit local production in the informal sector or prevent local entrepreneurs from developing their own version of the metal stove.

The "top-down" approach is one of diversification. Most towns in Botswana have some kind of metal shop or small factory. One organization that stands apart is the Botswana Brigade (BRIDEC), which is also involved in small-line manufacturing. It is possible that given a period of close collaboration with BRET Technical Coordinators the stove program could be carried out further with much less involvement of BRET personnel and time.

Having undertaken a training program to build stoves is not enough to ensure continuous output of the technology, however. From trainees and casual laborers to skilled producers is a gradual process, calling for continued technical and financial assistance in the form of materials, tools and equipment, as well as help with building inventory and marketing capability. If a self-sustaining dissemination is to take place, there must be a close relationship between costs and benefits, as they are perceived at the local level. It has been observed that training local artisans and people to provide follow-up does not necessarily correlate with output, but involves considerable resources and time, long after the initial training.

Recently, an example of that situation happened in which no rivets could be purchased from the local suppliers. The needed type of sheet metal was also often unavailable. These situations do not really affect the industrial sector as it can buy materials directly from the mill in the Republic of South Africa. Having to go through retailers will always involve an uneven flow of supplies. The small volume of production is partially responsible for this situation, at least in the informal sector. However, there are solutions to developing the capacity for stove production. One would be to provide supplies and technical assistance services to the informal sector. Another would be to concentrate on parastatal organizations, such as BRIDEC, which has the capapcity to order, handle and store large quantities of supplies. Yet another would be to depend heavily on the manufacturing sector, which is well organized to guarantee its inventory and offer reasonable delivery and output.

C. Features and Advantages of the BRET Metal Stoves

The BRET stoves are lightweight, easy to carry around, and have minimal absorption and conductive heat loss. It is inexpensive to buy, attractive and built to last, versatile in the range of pots and pans it accommodates, and shortens cooking time and smoke level as well as improving safety in the kitchen area. It can also be used as a space heater. Promoting these features would go hand-in-hand with stove production.

APPENDIX A

Supplemental Research on the Delta 3 and 6 Metal Stoves

More research is needed to size match the inside wall diameter on both the new stove models (Delta series). At present, they are sized 24cm and 28cm in diameter, respectively. The convection potential could be further investigated by reducing those numbers by a maximum of 3cm of the present diameters to 21cm and 25cm, respectively, leaving just enough space for the more popular pot legs to clear the inside wall.

The number of holes in the grate would have to remain the same. This would necessitate regrouping them in a similar but closer pattern.

The fuel-efficiency value and time value differences created by different pot sizes remain to be evaluated. The object, however, is to achieve the best possible efficiency regardless of pot size, as people already own pots of varying sizes and cannot be expected to replace them for use with a new stove.

Most people use cast-iron pots--size #1 and three-legged pots appear to be the most popular. However, a series of tests should also be performed using flat-bottom, aluminum pans. This is due to the fact that, in urban areas, aluminum pans are used much more frequently than cast-iron pans. These are cheaper and widely available in different sizes. The change in inside wall dimensions of the stove would no doubt influence convection and the burn rate. This could involve a lengthy series of tests despite its apparent simplicity.

APPENDIX B

Selecting a Metal-Stove Production/Dissemination Coordinator

To insure that the stove program has a long-term future, it would be advisable to hire someone with an interest in the welfare of Botswana and the following qualifications:

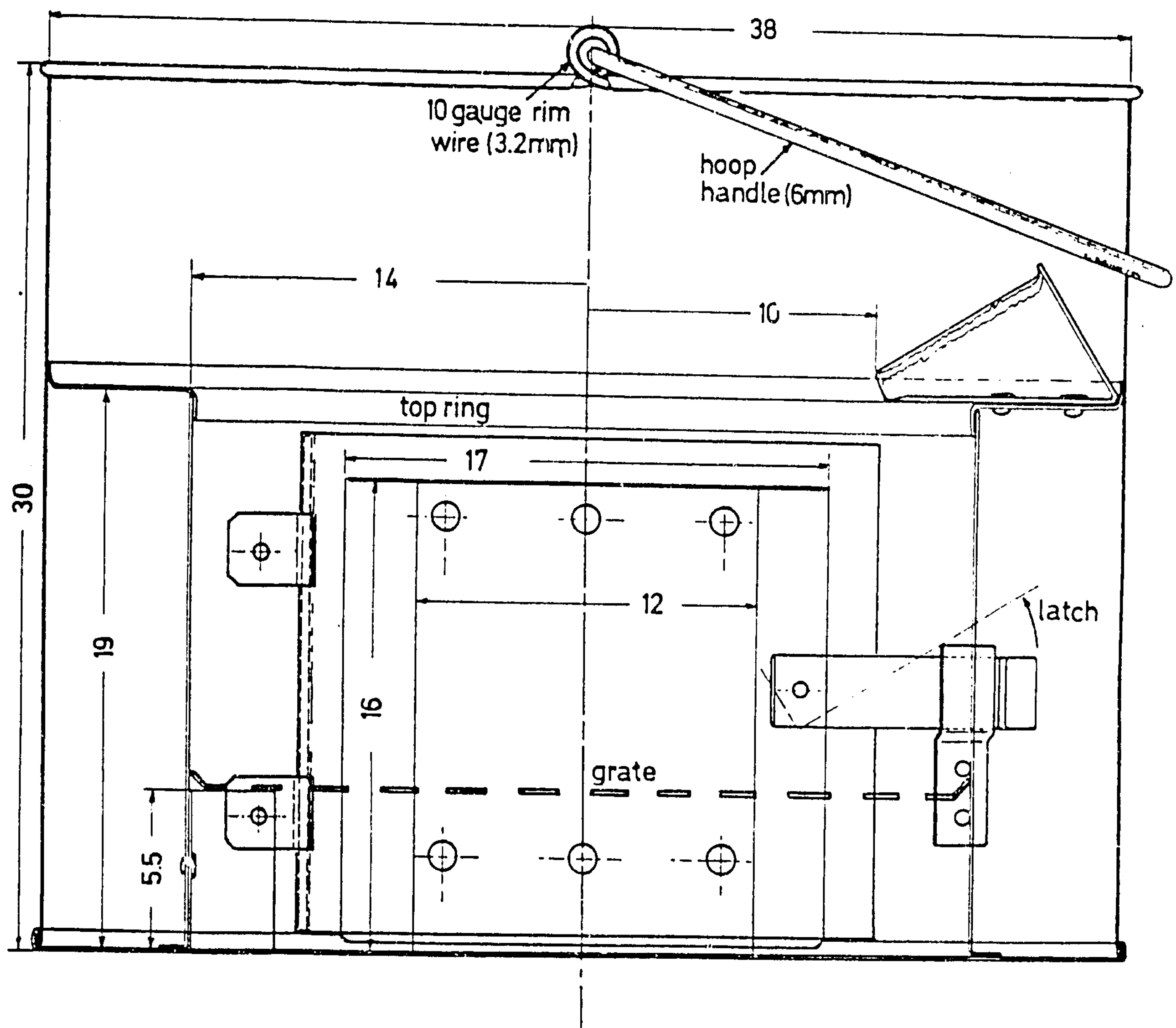
- at least two years' experience in commercial venture;
- the ability to participate in and understand production and training programs directed at the informal sector, the parastatal sector and the industrial sector;
- the ability to develop a production and dissemination program based on the existing plan with three-level production strategy;
- the ability to establish procedures for monitoring the effectiveness of the production/dissemination support team;
- the ability to plan and manage the production and dissemination aspect of the stove program with the assistance of the BRET technical staff and coordinator;
- the ability to assist in the development of materials, sales techniques for public awareness campaigns on energy conservation, based on the wide use of metal stoves;
- the ability to develop a network of sales agents, based in both rural and urban areas, and to establish a volume sale bonus system to stimulate growth in these sectors; and
- in conjunction with the BRET Technical Coordinator, the ability to select appropriate dissemination strategies and identify a suitable extension team with whom the project would work to disseminate metal stoves.

The skills required would include an understanding of urban social/economic environments and the ability to communicate well within those settings, the ability to understand and use training materials evolved during the metal stove development, and to interrelate with production groups concerning the technical materials needed to support the objective of the production and dissemination program. This person should also be able to work well as part of an interdisciplinary team and to understand how production/dissemination efforts fit into overall project objectives, to determine quality standards in the three levels of the production system and relate to them in economic and output terms, and the ability to communicate well with both producers and users.

Other specific qualifications should include a degree in engineering and economics with some experience in production, extension and dissemination planning.

code	description	page	number	gauge
1	Outside wall(OW)	4	1	0.8
2	Door (DR)	2	1	0.8
3	Door hinge (D.H)	2	2	0.8
4	Door latch (D.L)	2	1	0.8
5	Door lock (LK)	2	1	0.8
6	Bottom plate(B.P)	3	1	0.8
7	Grill handle (GL)	3	2	0.8
8	Inside wall (I.W)	5	1	1.0
9	Top ring (T.R)	2	1	1.0
10	Grate support(G.S)	1	3	1.0
11	Pot pad (P.P)	1	3	1.6
12	Grate (GR)	1	1	1.6
13	Grill (G)	3	1	exp. met.
14	Edge tracing gauge	1		

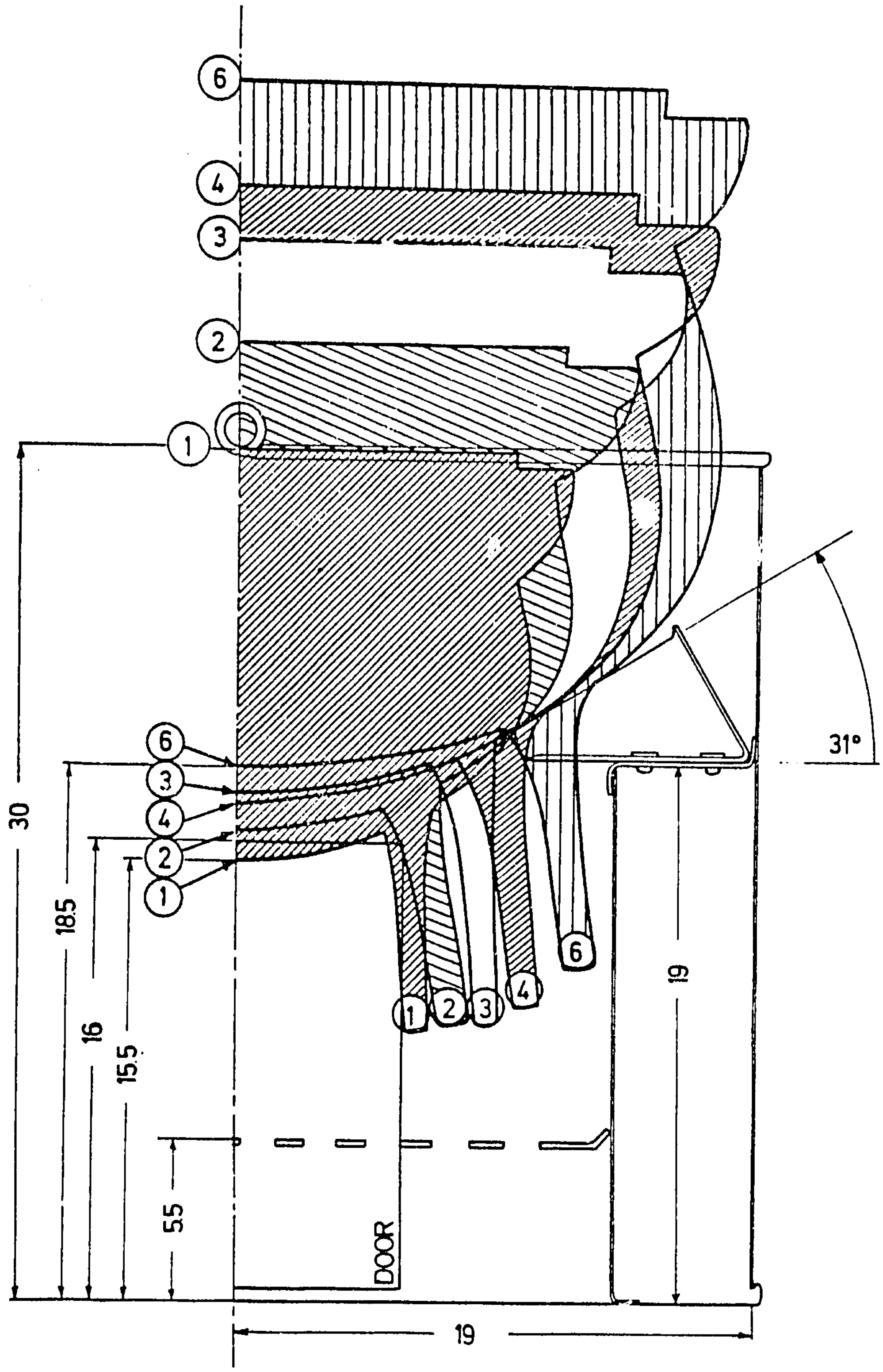
SUPER "B" MODEL
BRET METAL WOODSTOVE 2/84
general x.view
Scale:Full

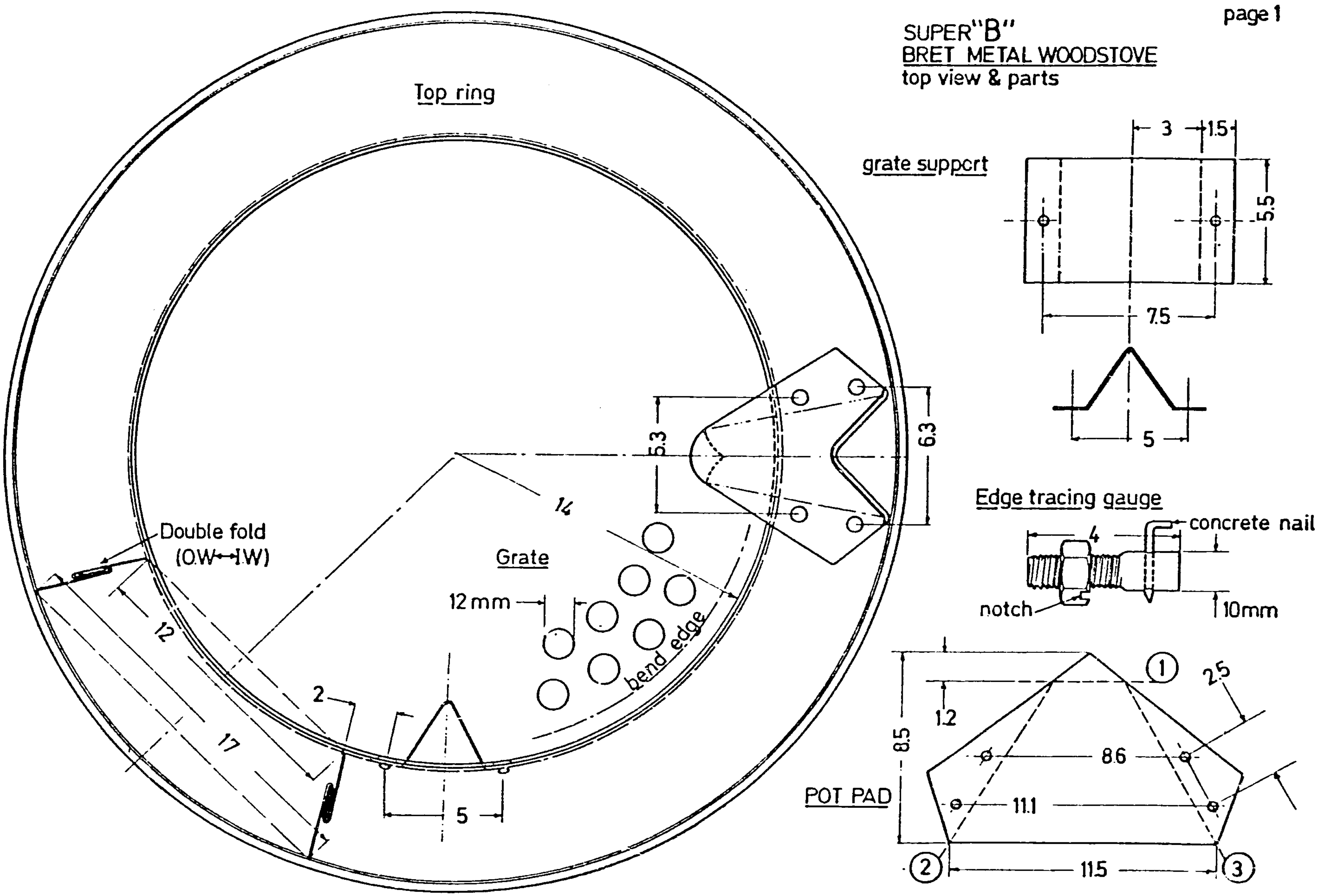


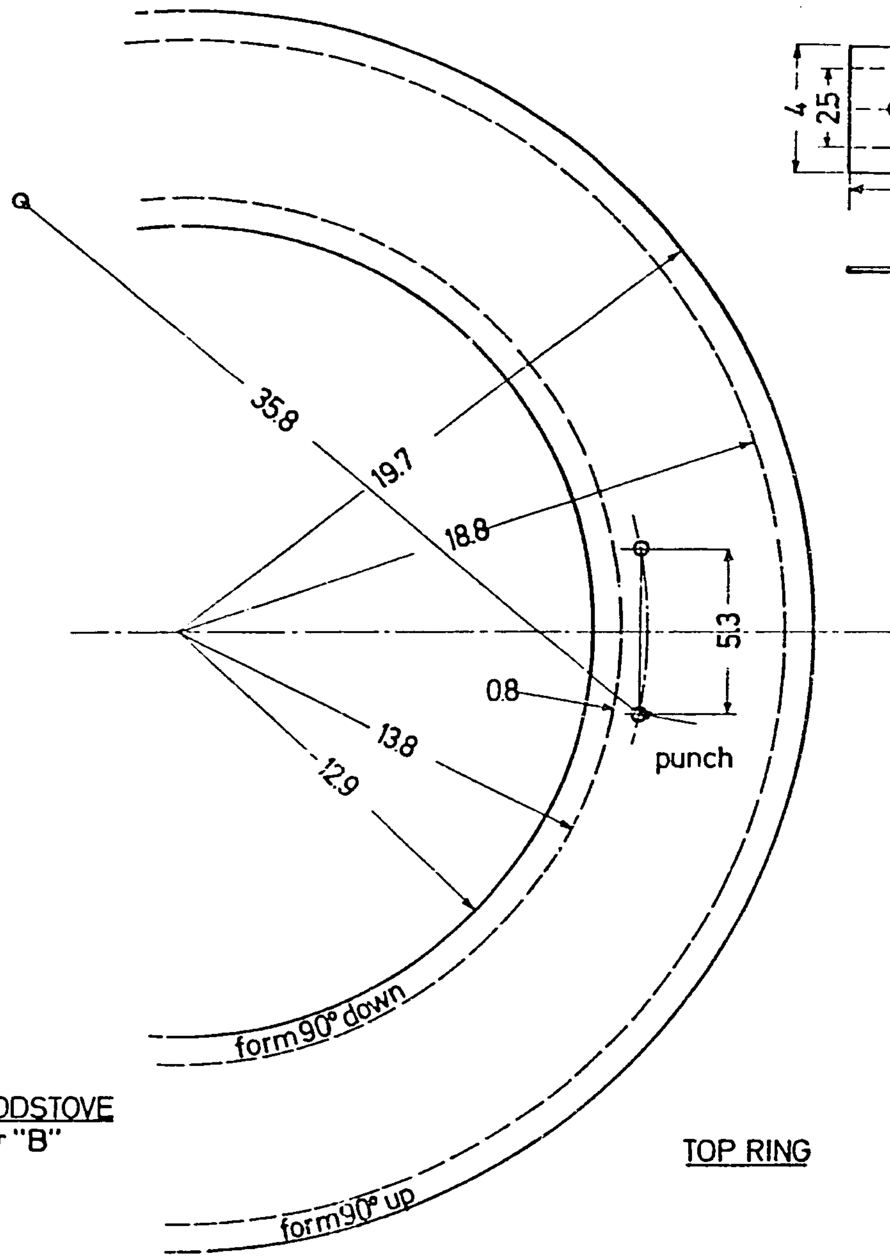
BRET METAL WOODSTOVE

Model super "B"

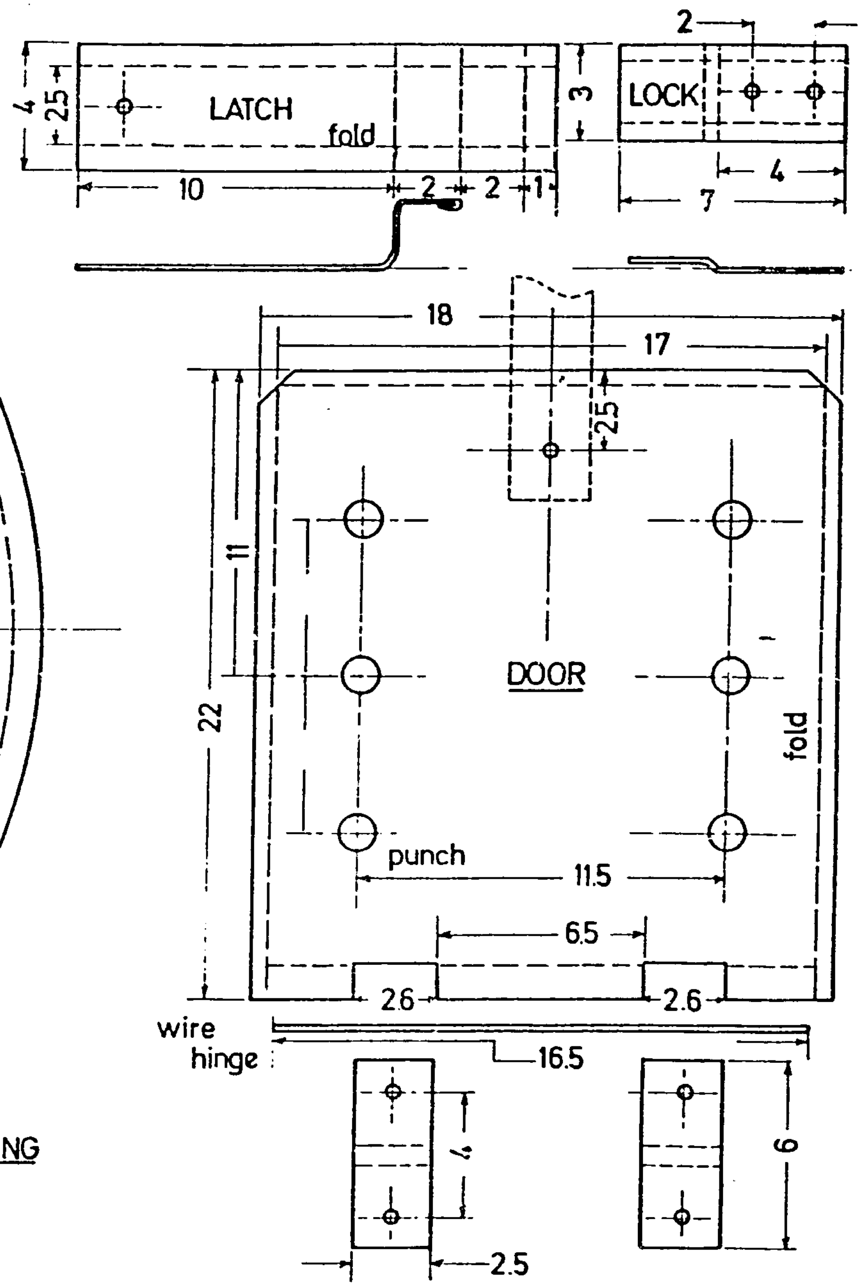
Profile layout of sizes: 1, 2, 3, 4, & 6.
cast iron 3 legged pots.




page 1
SUPER "B"
BRET METAL WOODSTOVE
top view & parts
Top ring
grate support
3
1.5
5.5
7.5
5
5.3
6.3
14
Double fold
(OW↔IW)
Grate
12 mm
bend edge
12
17
2
5
Edge tracing gauge
4
concrete nail
notch
10mm
POT PAD
1
2
3
2.5
1.2
8.5
8.6
11.1
11.5

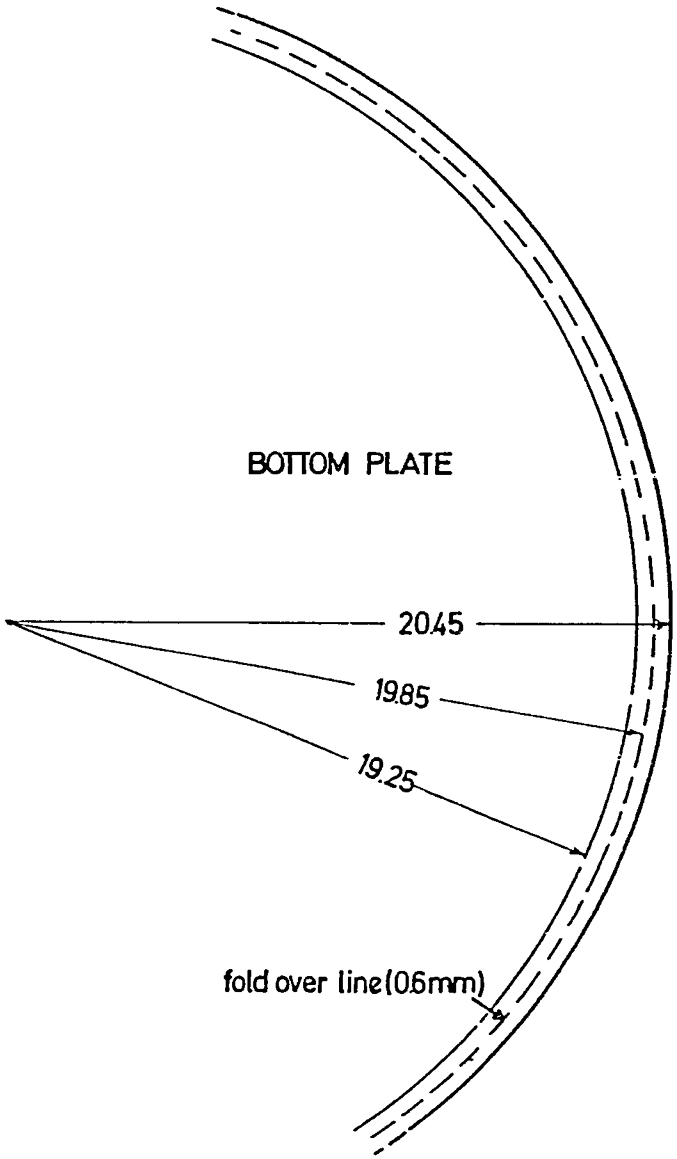


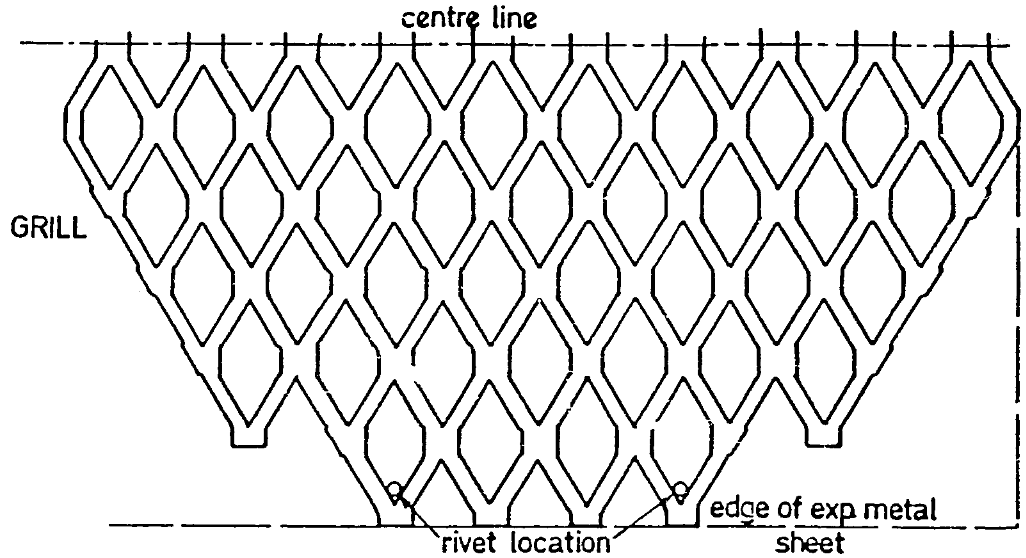
TOP RING

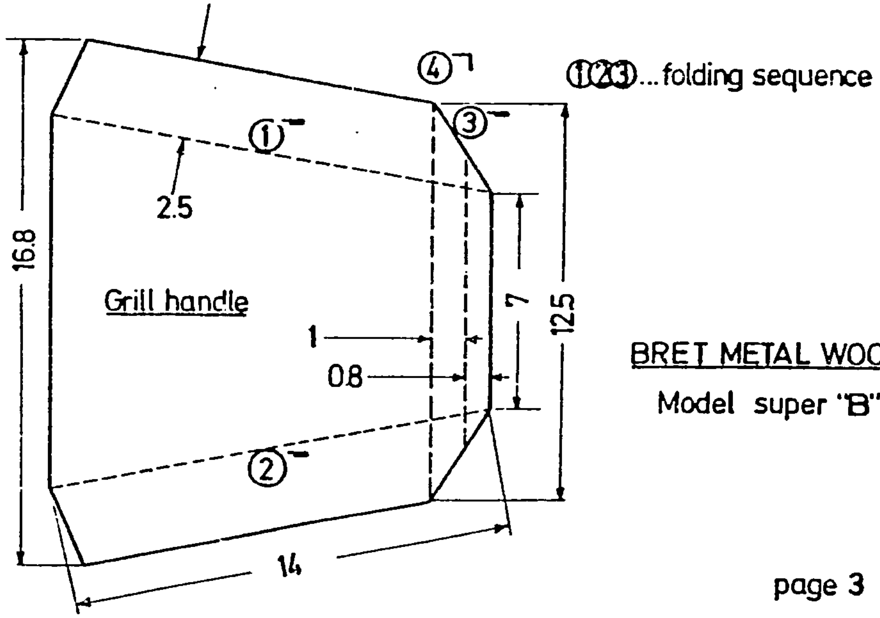


BRET
METAL WOODSTOVE
Model super "B"

page 2

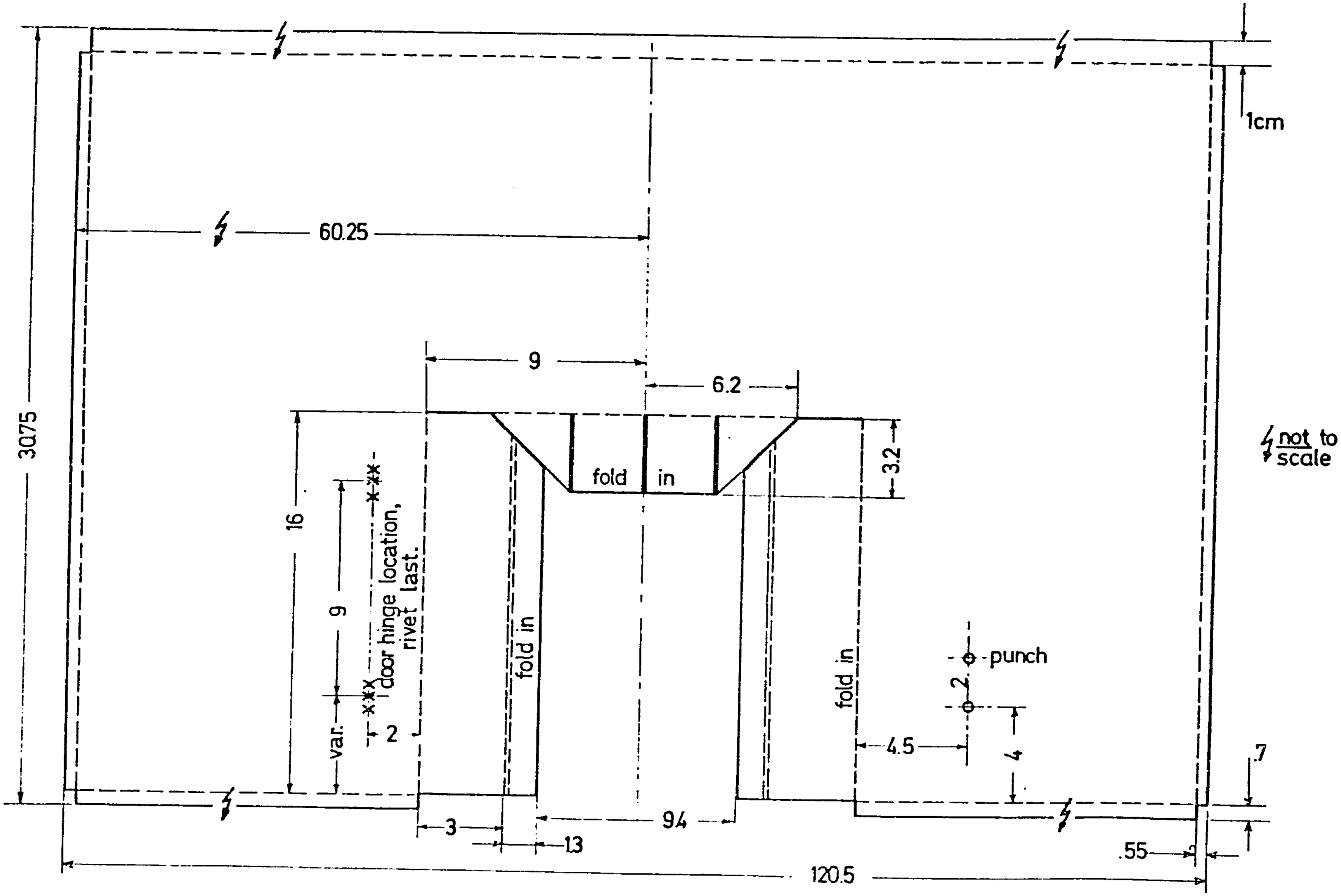






BRET METAL WOODSTOV

Model super "B"

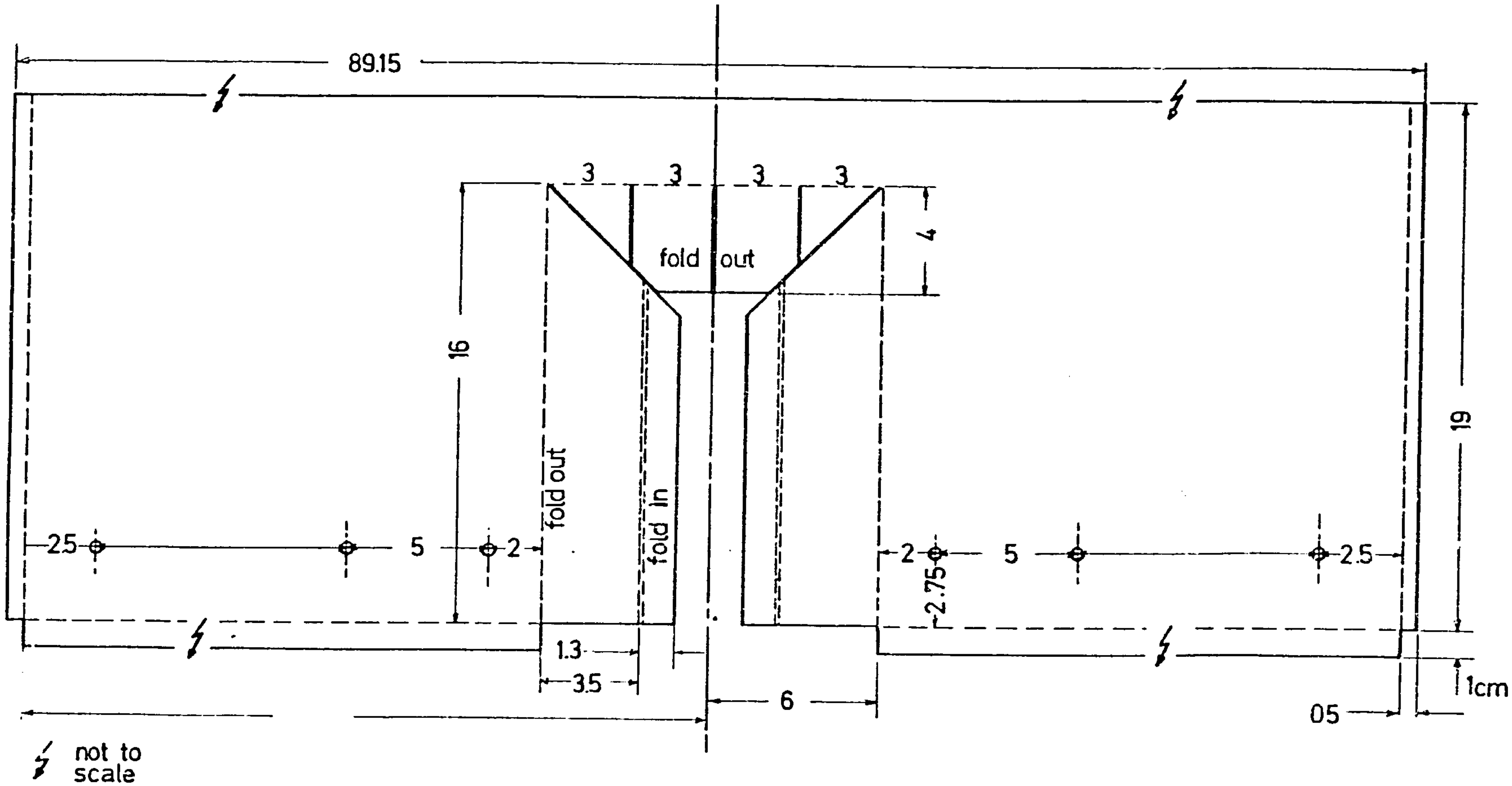


page 4

super "B"

BRET METAL WOODSTOVE
(outside wall)

36



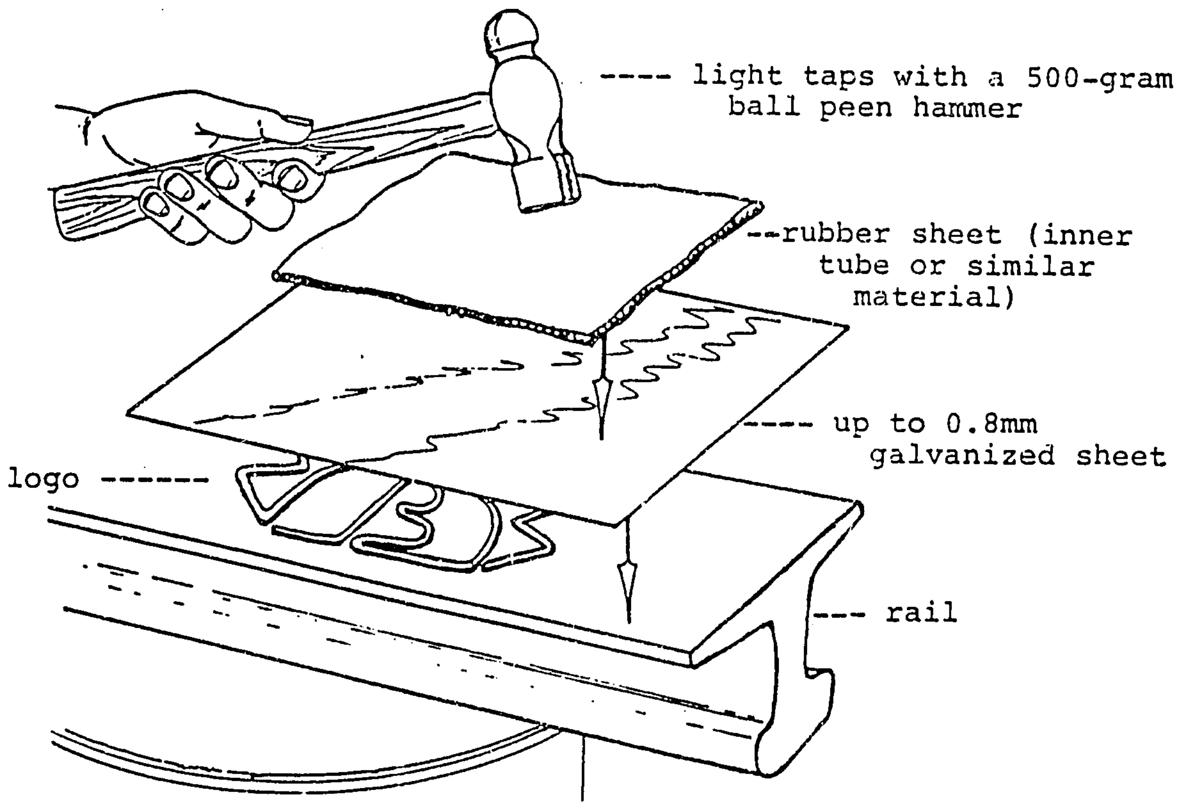
BRET METAL WOODSTOVE

Model Super "B"

(Inside wall)

APPENDIX D

One traditional Mazazuru technique to stamp simple ornaments on galvanized sheet metal wares has been adopted to give the BRET line of metal stoves a distinctive appearance. (Some early comments pointed out that the stove was a water pail look-alike.) A cast iron jig was designed to produce even-angled wire.



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