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DOMESTIC WATER HEATER

DESIGN PROJECT REPORT
PHILIP KENNY
INDUSTRIAL DESIGN
NIHE · NCAD
JUNE 1981

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THE NATIONAL COLLEGE OF ART AND DESIGN, DUBLIN

THE NATIONAL INSTITUTE FOR HIGHER EDUCATION, LIMERICK.

DOMESTIC WATER HEATER

A PROJECT REPORT BY PHILIP KENNY, FINAL YEAR STUDENT, DEPARTMENT OF INDUSTRIAL DESIGN (ENGINEERING) SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE DEGREE.

MAY 1981.

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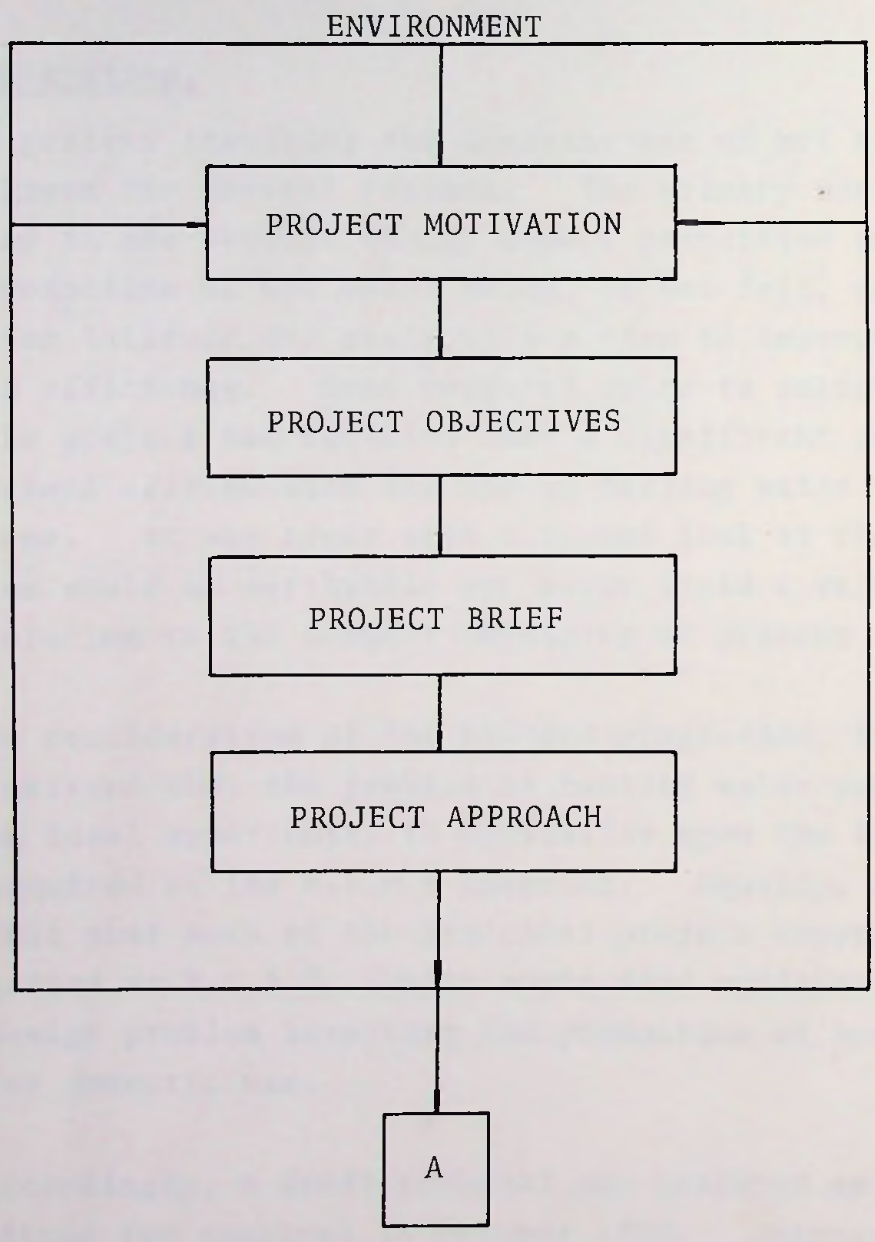
INTRODUCTION

TO

PROJECT



This project was initiated with the submission of a project proposal which included a description of:

- the motivation for choosing the project.
- the objectives of the project chosen.
- the nature of the project chosen.

The essential details of the original proposal are related here in order to set the chronology of this report from the start.

Motivation.

A project involving the domestic use of hot water was chosen for several reasons. The primary motivation lay in the obvious energy aspect associated with the production of hot water which, it was felt, afforded some latitude for study with a view to improvements in efficiency. Some research prior to selection of the project had revealed that a significant safety hazard existed with the use of boiling water in the home. It was clear that a closer look at the problem would be worthwhile and might yield a valuable solution to the dangers obtaining at present.

As consideration of the project progressed, it was realised that the problem of heating water provided an ideal opportunity to capitalise upon the knowledge acquired at the N.I.H.E Limerick. Equally, it was felt that much of the practical project experience gained at N.C.A.D, Dublin would find application in a design problem involving the production of hot water for domestic use.

Accordingly, a draft proposal was prepared and submitted for approval in October 1980. Approval was granted before the end of that month.

Objectives.

A series of project objectives were included in the draft proposal and these are repeated here to place the project brief in context:

Short-Term Objectives.

1. To establish a case for a fresh approach to designing domestic water heating/boiling appliances through identification of user needs.
2. To conduct a study of these needs with a view to developing solutions to the problems identified.
3. To develop these solutions towards an integrated product concept using a methodological design approach.
4. To execute a visual presentation tracing the project's development, to produce a prototype which represents a material response to the needs identified. To produce a comprehensive project report.

Long-Term Objectives.

1. To demonstrate the value of industrial design to Irish Industrialists.
2. To make a positive contribution to the conservation of energy campaign.

Brief.

A description outlined in the project proposal about to be undertaken acted as the basic project brief. This brief is reproduced here.

> "It is proposed that a study be made of a single activity which, it is felt, will offer a design development opportunity spanning both functional and aesthetic elements association with product design. The study will be centered around the

activity of heating small quantities of water in the home, with particular emphasis on hot water used in the kitchen area. Preliminary investigations have suggested that a review of existing appliances will reveal their considerable limitations.

Specific aspects of water heating appliances under review will be efficiency, safety, aesthetics and ergonomics. It is hoped therefore that the following will be in evidence in any design solution (s) that may be adopted.

- high efficiency in terms of output of hot/boiled water over input of energy.
- a high in-use safety factor.
- a communicative, responsive and pleasant interface between user and system.
- features which will rely on recent technology for their function.
- other features which will arise:

  A. from a precise definition of the problems posed.
  B. as a result of the research and analysis of data collected through literature searching, experiments and correspondence".

Project Approach.

It was realised at the outset that a rigorous project schedule needed to be devised and enforced to ensure that the deadlines of its various phases might be met on time. The Planner shown (Table 1) became operational on October 20, 1980 and the target date for completion of major work was set at May 20, 1981.

As daily "Schedule and Progress Sheets" were maintained it was possible to determine the degree of adherence to the Planner at any stage during the project[1]. Revisions could therefore be made where appropriate. It is interesting to compare the actual progress of the project with the Planner (Table 2).

Despite delays the project followed the course mapped out and the body of this report is laid out as per the chronology of the Planner. The text is divided into five sections. Section One represents the Research Phase, Section Two deals with the Design Phase, and Section three traces the Development Phase. A discussion of the project and the solution arrived at, with conclusions and recommendations is contained in Section Four. Section Five comprises the Appendices and carries the reference material and footnotes referred to throughout the text.

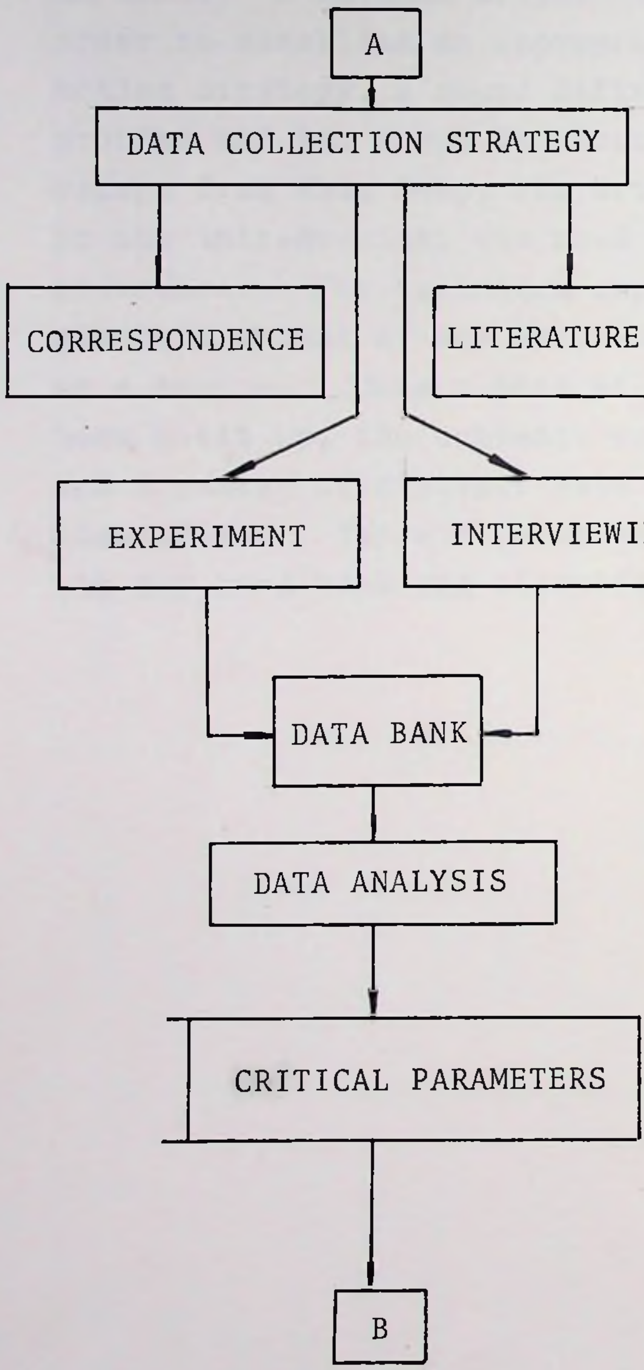
DATE	PROGRAMME OF EVENTS
NOVEMBER	DATA COLLECTION
DECEMBER	DATA COLLECTION DATA ANALYSIS
JANUARY	DATA ANALYSIS IDENTIFICATION OF CRITICAL PARAMETERS
FEBRUARY	PRELIMINARY IDEAS DEVELOPMENT OF SUBSOLUTIONS
MARCH	REFINEMENT OF OPTIMUM SOLUTION THROUGH MODELLING, TESTING
APRIL	DEVELOPMENT OF PROTOTYPE REPORT WRITING
MAY	DEVELOPMENT OF PROTOTYPE PRESENTATION WORK.

TABLE I. PROJECT YEAR PLANNER

DATE	PROGRESS OF PROJECT
NOVEMBER	DATA SOURCE SOURCING
DECEMBER	DATA SOURCING AND COLLECTION
JANUARY	DATA ANALYSIS
FEBRUARY	IDENTIFICATION OF CRITICAL PARAMETERS PRELIMINARY IDEAS
MARCH	DEVELOPMENT OF SUBSOLUTIONS ADOPTION OF FINAL SOLUTION
APRIL	DEVELOPMENT - ELECTRONICS AND MECHANICS
MAY	REPORT WRITING PROTOTYPE DEVELOPMENT PRESENTATION WORK.

TABLE 2. PROJECT PROGRESS.

SECTION 1. RESEARCH PHASE



1.1. DATA COLLECTION.

1.1.1. Introduction.

As a design solution may rely heavily on data collection and analysis of a problem, one naturally looks to the findings of the data phase for a clear definition of the problem in hand. A dilemma arises here in that in order to establish an appropriate data collection strategy, a sound definition of the problem and its scope is necessary. To escape from this loop, the brief, as outlined in the introduction, was used as a starting reference. The technique employed was to generate a bank of key words using the brief as a source. Once a bank of key words had been built up, the contents were classified and a number of distinct data areas were identified. Table 3 (overleaf) illustrates the key word bank and classification process.

Key Word	Associations			
Water	Quantity ✛	Temperature ✛	Purity ○	Softness ■○
Heat	Source ✛	Quantity ○	Transfer	Measurement ■
User	Behaviour ○	Requirements ○	Demands ○	Convenience ○
Water Heater	Appliances ✛	Features ○●	Historical	
Domestic	Kitchens ○	Bathrooms ○		
Efficiency	Fuels ✛	Losses ✛	Heat In ✛	Heat Out ✛
Safety	Scald ●	Burn ●	Spill ●	Explode ●
Operation	Interface ○	Controls ○●	Graphics ○	
Cost	Capital ○	Running ○	Manufacture ■	
Components	Type ■	Size ■	Quantity ■	Purpose ■
Materials	Type ■	Cost ■○	Aesthetics ○	
Maintenance	Assembly ■	Servicing ■		
Appearance	Aesthetics ○	Cleanibility ○		

TABLE 3. Identification of Data Areas.

Key: Energy Considerations. ✧
Safety Considerations. ●
Marketing Considerations. ○
Engineering Considerations. ■

1.1.2. Data Collection Strategy.

With four main data areas defined, it was possible to decide how best to source useful data. The techniques used were Correspondence, Literature Searching, Interviewing and Experimentation.

1.1.3. Correspondence.

Two distinct letters were drafted[2]. The first was intended to obtain information directly from manufacturers involved in the water heater business. The second letter was designed to include all other potential data sources and was phrased so as to allow the reader to select the particular data area(s) with which he/she might best be able to assist. In all sixty-six letters were issued, most being sent to Gt. Britain and the United States of America[3]. A total of thirty-eight replies were received, the majority of them yielding very useful information.

The addresses were sourced from the following Directories, and other miscellaneous publications not listed here:

Kellys Manufacturing & Merchants Directory.

European Directory of Published Market Research.

International Organisation of Consumer Unions Directory.

Europ Production - The Register of European Exports.

1.1.4. Literature Searching.

The literature search was divided into two categories: Books and Journals. It became clear early on that articles in journals would be a rich source of data. Accordingly, using a key word search system, several journal indices were consulted. These included:

The Applied Science and Technology Index-USA
The British Technology Index.
The Engineering Index.
The Electrical and Electronic Abstracts Index.

Each Index was consulted for the period 1970 - 1980 inclusive. A total of 35 highly relevant articles were located as a result of this search[4]. The articles were sourced at several locations.

Books were sourced for data purposes mainly as specific problems arose [5]. The exception to this is literature collected in connection with historical aspects of water heating which formed the basis for the companion piece to this report - a thesis submitted to the Faculty of History of Art and Design at N.C.A.D in April 1981.

1.1.5. Interviewing.

Throughout the project interviewing took place. In general these interviews were non-structured and were carried out as fact finding missions. Many experts were consulted[6] and much use was made of valuable data obtained from conversations with users.

1.1.6. Empirical Work.

In order to retrieve information by first hand experience, empirical methods were widely used most particularly with regard to establish thermodynamic data in connection with small water heating apparatus.

1.2. DATA ANALYSIS

1.2.1. Introduction.

The data analysis section treats of the Data areas defined in section 1.1.1. Its purpose is to present an overview of the data collection, their implications and their role as determinants of critical parameters. Data analysis however, is not confined to this section in the sense that decisions at the development phase were based on additional data used to arrive at specific sub-solutions. In particular, engineering considerations such as manufacturability, components and materials choice are dealt with following the commitment to a specific design solution.

The present section therefore, deals with energy, safety and marketing considerations in the context of water heating.

1.2.2. Energy Considerations in the Production of Hot Water.

(a) Basic Thermodynamic Considerations.

Water may be heated by three mechanisms - conduction, convection or radiation. Generally these mechanisms will obtain simultaneously in the heat transfer process discussed here. The business of an energy source or fuel is to bring about a transfer of heat by one of several possible methods - combustion of a substance, conversion of electrical energy to thermal energy, chemical reaction other than combustion, collection of solar radiation etc. Fundamentally, any water heating system comprises a mass of water to be heated and a heat source between which there must exist a temperature differential such that the heat will flow from the source to the water.

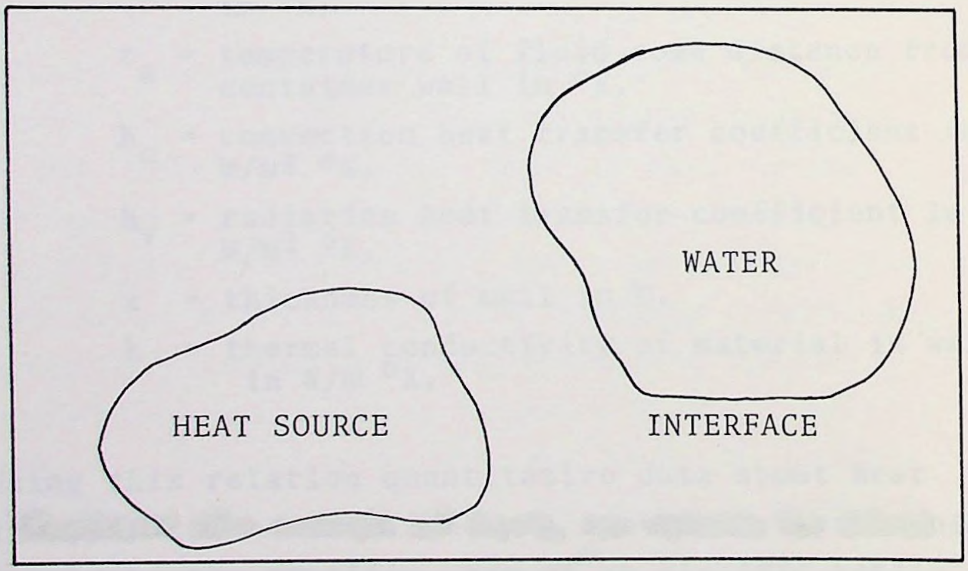


Fig. 1. SYSTEM

Whatever the source of heat, no system is ideal and losses occur both at the active heat transfer interface and at the other boundaries of the water "enclosure". The efficiency of a given system is dependent upon many factors. This is discussed more fully later in the analysis section. At this stage, however, it is useful to consider some of the terms at play in any heat transfer situation involving a fluid. These are:

Thickness of Container.
Thermal Conductivity of Container.
Surface Area and Configuration of Container.
Heat Source Configuration.
Motion of Fluid.
Physical Properties of Fluid.

As a first approximation, these parameters may generally be defined by the relation:

$$Q = -U\,(t_b - t_a) \quad \text{with}$$
$$1/U = \sum 1/h_c + h_r + \sum \Delta x/k.$$

where Q = heat transferred in KJ.
U = overall heat transfer coefficient in $W/m^2\ {}^oK$.
t_b = temperature of fluid at container wall in ${}^oK$.
t_a = temperature of fluid some distance from container wall in ${}^oK$.
h_c = convection heat transfer coefficient in $W/m^2\ {}^oK$.
h_r = radiation heat transfer coefficient in $W/m^2\ {}^oK$.
x = thickness of wall in m.
k = thermal conductivity of material in wall in $W/m\ {}^oK$.

Using this relation quantitative data about heat transfer can be obtained. A number of experiments involving the specific case of an electric kettle's efficiency were carried out with calculations based on this relation. The findings of these experiments are presented in section 1.2.2.e. For the present, it is appropriate to return the discussion to a more general approach to energy considerations in the production of hot water.

(b).Appliances, Fuels and Efficiency.

Current emphasis on energy conservation arising from increases in energy costs has resulted in keen interest in the efficiency of water heating appliances. Many difficulties arise when attempts are made to identify the most efficient methods of heating water. Appliance efficiency is usually considered on two levels: firstly in terms of the energy source used, from a primary versus secondary energy utilization standpoint; secondly in terms of how efficiently that energy is transferred to a mass of water by an energy conversion process. Consideration of water heating appliance efficiencies with reference to only one of these factors is apt to give an unbalanced view of an appliance's real cost effectiveness, since energy costs and quality may vary and appliance operating conditions can alter.

The appliance/energy efficiency debate has many facets and it is worth developing some aspects of the discussion here. This is best viewed through the traditional argument for direct utilization of cumbustible fuels as against conversion to electricity, most commonly witnessed in the gas versus electricity debate, and has particular significance in water heating applications. Miles has pointed out that the overall generation and distribution losses of electricity are such that for every two units of primary energy consumed in the power station, on average only some 27 units reach the consumer [7]. In the case of natural gas , of 100 units of energy available at the well head, 94 units reach the consumer. Therefore in terms of appliance bench water generation efficiencies of 100% for electricity and 75% for gas, the utilization of primary energy gives overall efficiencies of 27 and 71% respectively.

Viewed in this way, the case against using electricity for water heating is very convincing. In practice however, 75% efficiency is not achieved in gas appliances. Furthermore, many other factors are at play in determining real appliance efficiencies. The most significant of these is appliance configuration. Non-electrical water heating appliances are almost universally characterised by losses at the heat transfer interface of the system a problem not significantly encountered in modern electrical water heating appliances. The two types of system may be simplified as in Fig. 2. The nature of combustion heat transfer methods is such that heat is necessarily lost in the form of expelled flue gases, and in the form of heat required to transfer through an often large interface.

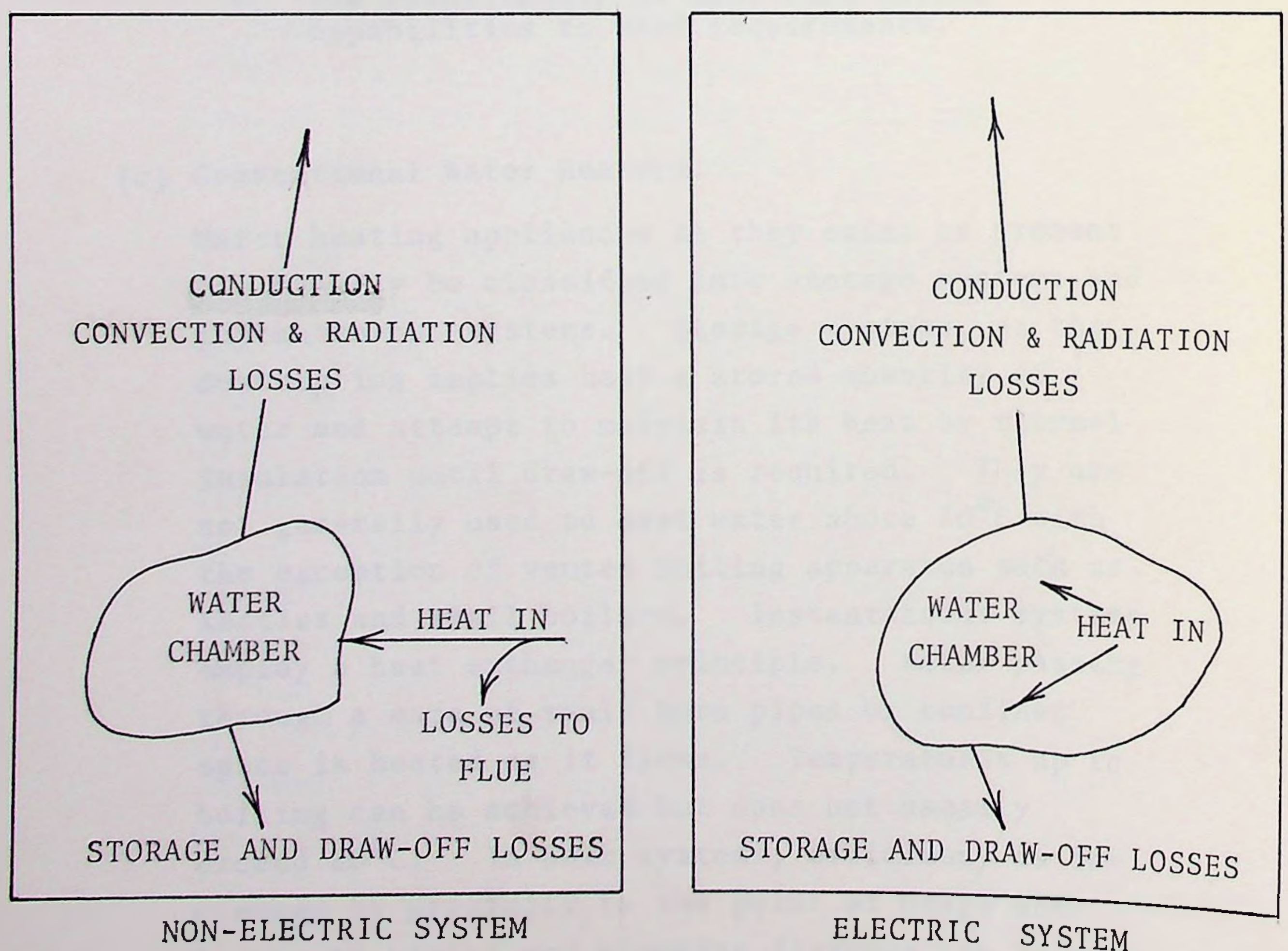


FIG. 2. Gas Versus Electric Systems.

The efficiency of any water heating system is also to a large extent, dependent on the requirements placed on it by its user. It follows that a system designed to heat a large quantity of water in bulk will be inefficient if only small quantities are required at widely dispersed intervals. Similarly, using small output appliances to provide large quantities of hot water with rapid successive continuous use will be inefficient.

In summary then, the factors influencing the efficiency of water heating appliances may be listed thus:

1. The use of Primary or Secondary Energy.
2. The useful conversion and transfer of that energy to water.
3. The degree of control of losses from the system.
4. The relationship of appliance output capabilities to user requirements.

(c) Conventional Water Heaters.

Water heating appliances as they exist at present may broadly be classified into storage systems and instantaneous systems. Storage systems, as the description implies heat a stored quantity of water and attempt to maintain its heat by thermal insulation until draw-off is required. They are not generally used to heat water above 70^{o}C with the exception of vented boiling apparatus such as kettles and small boilers. Instantaneous systems employ a heat exchanger principle. Water passing through a maze of small bore pipes or confined space is heated as it flows. Temperatures up to boiling can be achieved but does not usually exceed 80^{o}C. In both systems, efficiency is increased by proximity to the point of usage when losses to piping and plumbing fixtures can be minimised.

It is not possible to state whether one system is more efficient than the other - circumstances and usage patterns are critical in determining this. Myles has commented on this:

> "If only the provision of hot water is considered, instantaneous water heating is potentially the most efficient way whatever the fuel. This is because the heater operates only at times when heat is required and because any storage system inevitably has losses from the storage container. In practice the instantaneous heater need not necessarily have a higher efficiency than the storage system, especially if long pipe runs to the taps are involved".[8]

Instantaneous systems have the disadvantage of requiring very high energy input, particularly if high temperatures and fast water flow are requirements. Storage systems suitably lagged can produce the same temperature range but will take longer at a lower energy input.

How then can the user balance the equation? Both systems can perform to suit his requirements. The question arises as to what precisely are his requirements. The instantaneous system scores over the storage system in that it heats only the amount of water drawn off. It is questionable as to whether this is always the amount of water required since availability often promotes usage that might not otherwise take place. The kernel of the problem of hot water inefficiency lies in the users' inability to predetermine the quantity and temperature of water he wants to heat at any particular time. Most storage systems heat fixed quantities. Instantaneous systems are imprecise and potentially over-used. The problem therefore seems to be one of inducing the user to be specific about his needs. It is a question of control. It is fitting therefore that the requirements of users should be quantified. This is done in the marketing section of this data analysis.

(d) The Particular Case of the Kettle.

The ubiquitous kettle, be it electric or otherwise powered, presents the problem of user requirement specification well. At best, kettles are filled inaccurately with respect to user requirement and at worst, they are always filled whatever the need. For non-electric kettles this makes a very inefficient method of heating water even less so. For electric kettles, it can affect efficiency considerably. The British Electricity Council estimated that 13.5 million electric kettles are owned in the domestic sector in England and Wales. We can add a further 1.5 million if we include Ireland and the non-domestic ownerships such as industry and offices. This assumes therefore a conservative estimate of 15 million kettles in daily use in these Islands. The Electricity Council also estimates a typical annual consumption of 220 Kilowatt Hours per kettle per year. This implies a total annual energy consumption by electric kettles of 3.3×10^9 Kilowatt Hours.[9]

Now if we assume, again a conservative estimate of an average 10% inaccuracy over the required amount of water boiled per kettle per year, due to arbitrary measurement of water, we can calculate the energy wasted. Assuming constant specific heat of water, and boiling in all cases, the heat transferred redundantly is a function of mass only so we have energy wasted

$$= 10\% \text{ of } 3.3 \times 10^9 \text{ Kilowatt Hours.}$$
$$= 3.3 \times 10^8 \text{ Kilowatt Hours}$$

- a lot of energy.

Needless to say, electric kettles are not in fact 100% efficient, so this waste is compounded by other losses. A number of experiments were undertaken to determine the extent and causes of these losses. The purpose of the experiments was also to gain a practical knowledge of some of the thermodynamic phenomena at work in water heating.

(e) Heat Transfer in Electric Kettles.

Three experiments were undertaken. The first two were to find the efficiency of an electric kettle and to plot a cooling curve for water boiled in an electric kettle. The third experiment set out to identify and quantify the losses in the system.

EXPERIMENT NO. I.

To measure the efficiency of an electric kettle.

Procedure: Measure the total electrical energy into the system using a Kilowatt flour meter.
Calculate the heat transferred to the water using the relation

$$Q = MC\,(t_f - t_i)$$

where Q = heat transferred in KJ.
M = Mass of water being heated.
C = Specific Heat of WaterKJ/Kg ^{o}C.
t_f = Final temperature of water ^{o}C.
t_i = Initial temperature of water ^{o}C.

Mass Used = 1.5 Kg.

Time (Sec)	Temperature ^oC	Kilowatt Hrs. KWh
0	9.5	0.00
20	11.5	0.01133
40	17.0	0.0233
60	23.5	0.0353
80	29.5	0.0473
100	36.0	0.0593
120	43.0	0.0713
140	48.5	0.0833
160	55.5	0.0946
180	61.0	0.1066
200	67.5	0.118
220	74.5	0.1293
240	80.0	0.1413
260	86.0	0.1533
280	93.5	0.1653
300	98.0	0.1766

TABLE 4. Readings.

Result. Total energy in as measured.

$$1\ KW = 1\ KJ/s$$
$$1\ KWh = 1\ KJ/s \times 3600\ s$$
$$0.1766\ KWh = 3600 \times 0.1766\ KJ$$
$$= 635760\ J.$$

Total energy transferred to water

$$M = 1.5\ Kg, \quad C = 4.2\ KJ/Kg\ ^oC.$$
$$t_i = 9.5^oC \quad t_f = 98^o\ C$$

Therefore

$$Q = 1.5\ Kg \times 4.2\ KJ \times 88.5^o\ C/\ Kg^oC$$
$$+\ 557550\ J.$$

This implies a loss of 78,310 J or an efficiency of 87.6%.

Experiment No. 2.

To plot the temperature decay curve for water contained in an electric kettle.

Mass of Water: 1.5 Kg
Initial Temperature: 9.5 °C
Peak Temperature: 98.0 °C
Final Temperature: 41.0 °C

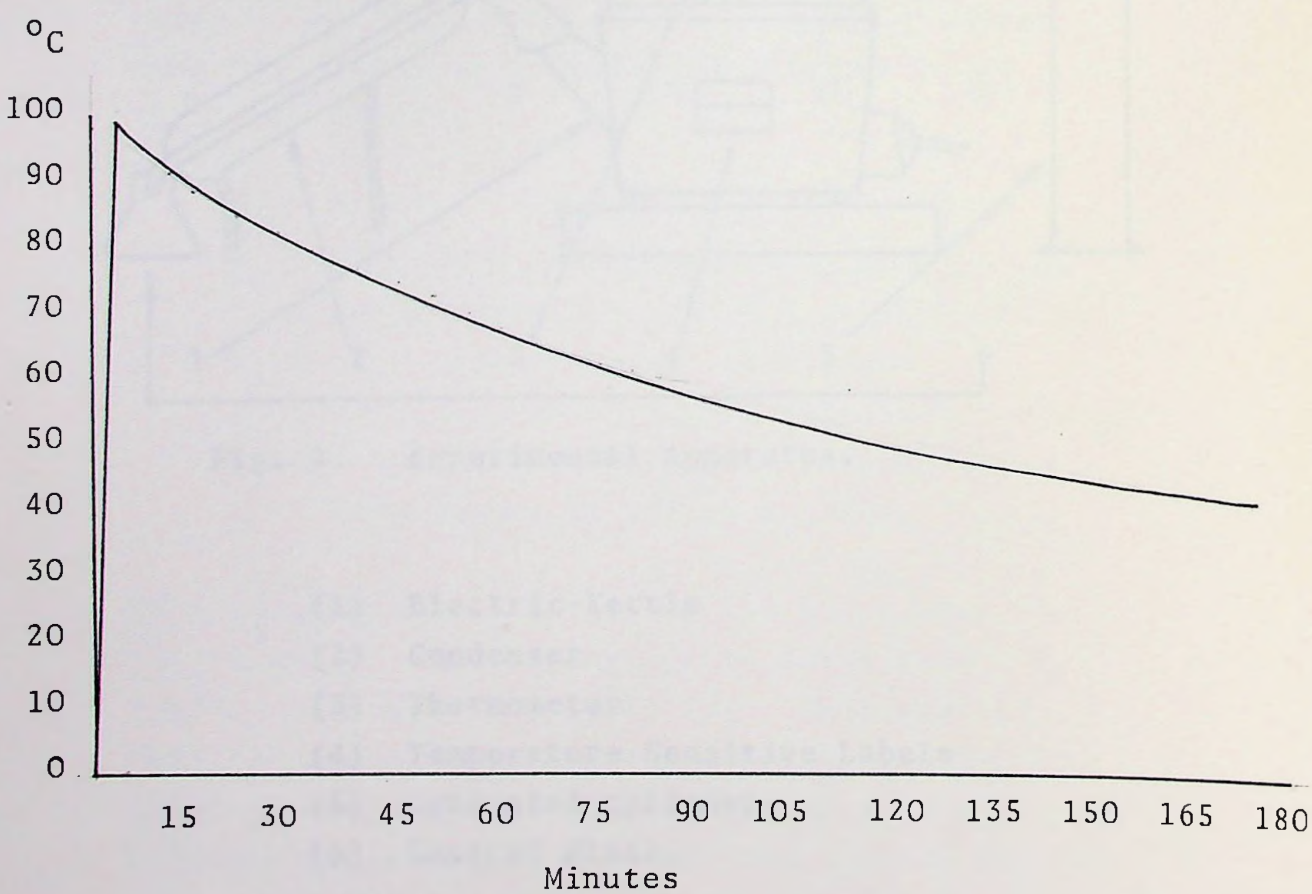


Fig. 3. Temperature Decay Curve for water contained in an electric kettle.

EXPERIMENT No. 3. To investigate the losses in an electric kettle and account for the 87.6% efficiency observed.

The following factors will account for most of the inefficiency observed.

(a) Heat stored in the kettle element and body.
(b) Conduction and convection losses to the external environment.
(c) Generation of Steam.
(d) Radiation heat transfer losses.

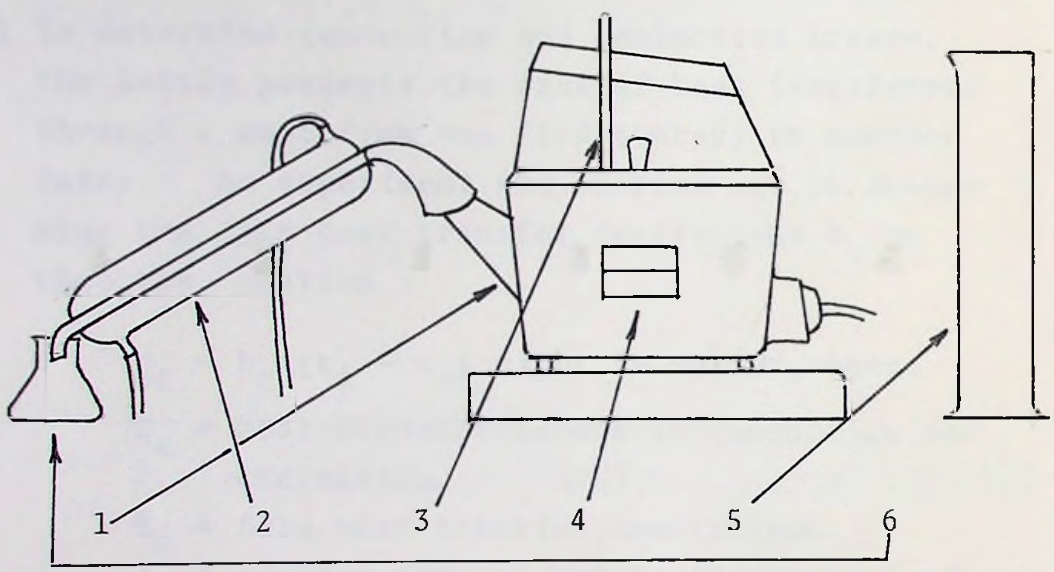


Fig. 4. Experimental Apparatus.

(1) Electric Kettle
(2) Condenser
(3) Thermometer
(4) Temperature Sensitive Labels
(5) Graduated cylinder.
(6) Conical Flask.

(a) To determine the heat stored in the kettle element and body: The kettle was boiled for several minutes. Contents were emptied and refilled with water of known mass and temperature. The corresponding rise in temperature was noted.

Mass of Water, M = 0.5 kg.
Initial temperature of water t_i = 10°C.
Final temperature of water t_f = 25.5°C.

Therefore, using $Q = MC(t_f - t_i)$, we have:
Heat stored in element and body

$$Q_{eb} = 0.5 \text{ kg} \times 4.2 \text{ KJ/Kg}^{\circ}\text{C} \times 15.5^{\circ}\text{C}$$
$$= 32550 \text{ J}$$

This leaves a loss of 45660 J unaccounted for.

(b) To determine conduction and convection losses. The kettle presents the case of heat transferred through a wall from one flud (water) to another (air). An experiment was carried out to determine the film heat transfer coefficient h_c so that the relation

$Q_c = h_c A(t_i - t_o)$ might be solved, where

Q_c = heat transferred due to conduction and convection.
h_c = film heat transfer coefficient.
A = surface area of kettle (Vertical Surface).
t_i = temperature of fluid at inside.
t_o = temperature of air on outside.

When determining t_i and t_o it was found that at all stages of the boiling cycle, these were virtually identical (See table 5). This implied that the conduction term which would normally be added to the above relation could be neglected, and calculations could be made for one side of the wall only - the "air" side.

The only unknown in the above relation was h_c. h_c had to be calculated for each individual temperature reading between 10°C and 100°C. Rogers and Mayhew (1967)[10] have quoted average values of

h_c for a vertical plate or cylinder in air in laminar or transitional motion at atmospheric pressure:

$h_c = 1.42 \left[\theta/1\right]^{\frac{1}{4}}$ W/m$^{2\,o}$K where θ is the mean temperature of the fluid at the wall.

Kettle Radius = 0.1 m.
Kettle Height = 0.09 m.
Therefore Kettle Vertical Surface Area = 0.0565 m^2
Air Bulk Temperature = 18^{o}C.

Sample Calculation for Water in Kettle at 100^{o}C:

$h_c = 1.42 \left[(100+18)/2 + 273 \quad /0.09\right]^{\frac{1}{4}}$ W/m^2 ^{o}K
= 11.066 W/m^2 ^{o}K
And
Q_c = 11.066 W/m^2 ^{o}K. 0.0565 m^2 . 82^{o}K.
= 51.268 W

And assuming that each degree K of temperature was maintained for 3 seconds we can get an average total loss of

153.8 at 100^{o}C.

Repeating this calculation for each temperature interval, we get a total loss due to convection heat transfer of
6277 J.

This leaves 39,383 J unaccounted for.

(c) Generation of Steam.

So far, only sensible heat losses have been accounted for. A small quantity of steam is generated when a kettle is boiled. This steam was recondensed and the quantity noted - approximately

3 grams. Additional steam also condensed on the inside lid - approximately 5 grams. This gives a total mass of steam generated = 0.008 Kg.

If we assume that the bulk of this steam is raised at 100^{o}C and at atmospheric pressure we can estimate the heat lost due to evaporation by multiplying the mass of steam generated by the Specific Enthalpy h_{fg}. Thus, we have

$$0.008 \text{ Kg} \times 2256.9 \text{ KJ/Kg}$$
$$= 18055 \text{ J.}$$

This leaves 21,328 J unaccounted for.

Inside Wall Temperature ^{o}C	Outside Wall Temperature ^{o}C
10	-
20	-
37	37
40	40
43	43
46	46
50	49
53	54
60	60
65	66
69	71
76	77
82	82
87	88
93	93
98	99

Table 5. Kettle Wall Temperature Readings.

(d) Radiation Heat Transfer Losses.

The balance of heat lost is due to radiation losses plus losses unaccounted for due to experimental errors and limitations - for example, heat stored in the kettle handle was not accurately determined etc.

(f) Energy Considerations - Conclusions.

For Efficiency:

1. Water to be heated must be accurately controllable in terms of quantity.
2. Water to be heated must be accurately controllable in terms of temperature.
3. Heat loss through water enclosure must be minimal.
4. Boiling duration and intensity must be minimised.

1.2.3. Safety Considerations in the production and use of hot water.

THE HASS

Safety in the production and use of hot water proved to be the most critical parameter in the design criteria ultimately employed. Data received from the Home Accident Surveillance System (HASS) in the U.K. suggested that a major rethink be undertaken in water heating appliance design from the safety viewpoint. The HASS was set up in 1976 to collect data on product-related accidents occurring in the home. The system is operated through the Accident and Emergency Departments of twenty hospitals offering a twenty-four hour casualty service. For a given accident the data recorded includes a description of the accident, the product or features of the home involved and the injury incurred. Data regarding age and sex are also recorded.

These data are available to the public in the form of computer listings by product category[11]. The data reproduced here is based on such a listing.

Two case listings are of particular relevance to the present project. The first is concerned with accidents involving water heaters.and its findings are shown in Fig. 5 in condensed form. Immediately one is struck by the large proportion of accidents resulting from collision with appliances. While this problem has to be viewed seriously it must be realised that this type of accident occurs generally in the home and is not specific to water heaters. Due note however, has been taken of the type of injuries incurred, many of which include cuts and bruises from sharp edges particularly those of bent metal forms that are common in water heater and boiler housing units.

More serious injuries resulted from accidents involving gas appliances. These were of two types:

1. Burns from gas explosion due to leakage or build-up of gas during ignition.
2. Asphixiation from fumes whilst using gas appliances.

These injuries account for 45 of the accidents listed. There have always been difficulties with gas, yet it is surprising that such a high accident rate persists in an age when control is well mastered. It is worth mentioning at this point that the HASS does not record fatalities due to product related accidents, so the number of accidents listed here may well fall short of the total number that may have occurred during the time of and at the location of recording.

Equally serious injuries were sustained due to scaleds from hot water. Significantly many of these scalds were incurred by the very young. A.W. Wilkinson has tabulated the average numbers of deaths due to scalds for the period 1931 to 1972.[12] (Tab.6) It is encouraging to see that deaths due to scalds have fallen drastically. However, as scald deaths in the past resulted from infection after the accident, these figures do not mean that the number of scald accidents taking place has declined.

The widespread use of kettles for boiling water accounts for many serious accidents involving hot water. The second HASS case listing studied revealed a high risk to the very young where kettles were involved. The findings of the case listing are reproduced in Fig. 6 and Fig. 7 in condensed form. Two features are outstanding. The first is that the bulk of accidents with kettles are related to the portability of the appliance. The second is the very high number of children under the age of ten years who suffer scald accidents from kettles. Wood has pointed out in 1974 the scald injuries resulting from kettle accidents arose from six identifiable causes:[13]

1. Steam emission 20%.
2. Hot water spilled while being carried 17%.
3. Hot water spilled when knocked over 31%.
4. Hot water from spout when pouring 21%.
5. Hot water from lid when pouring 1%.
6. Whistle top blowing off and water ejecting 6%.

Total Number of home accident records included in this analysis 149.

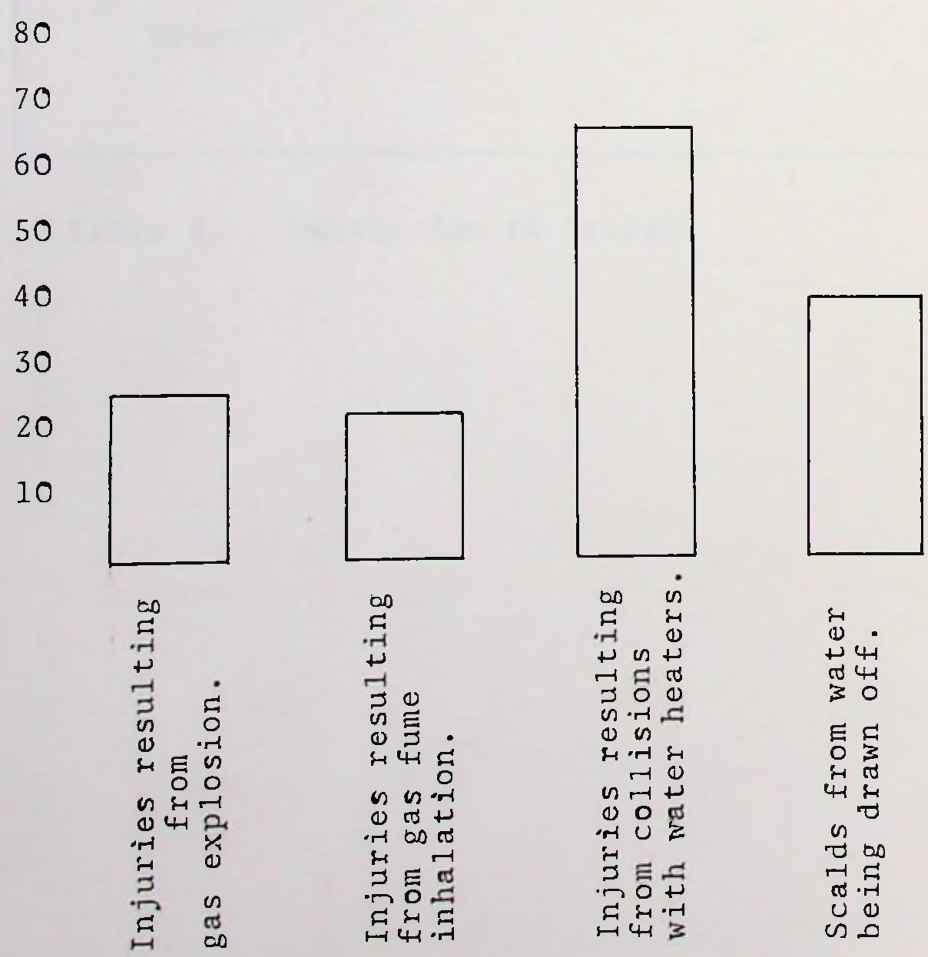


Fig. 5. Accidents involving water heaters.

PERIOD	NO. OF SCALD DEATHS
1931-35	371
1945-49	
1950-54	58
1955-59	31
1960-64	22
1968-72	11

Table 6. Deaths due to Scalds.

Fig. 6. Properties and features of a listing of 181 kettle accidents recorded by the HASS for the period 23.10.78 to 6.1.80.

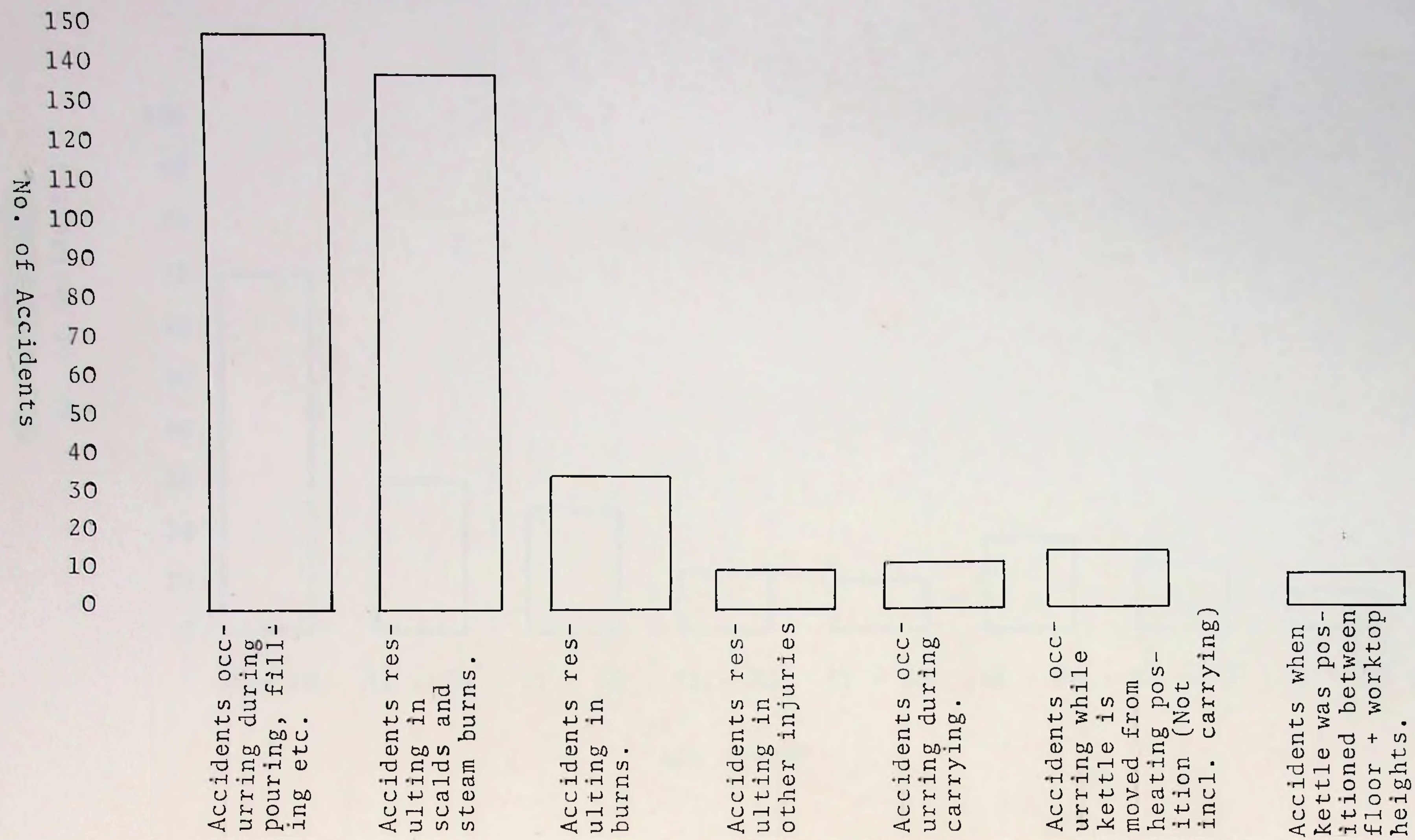
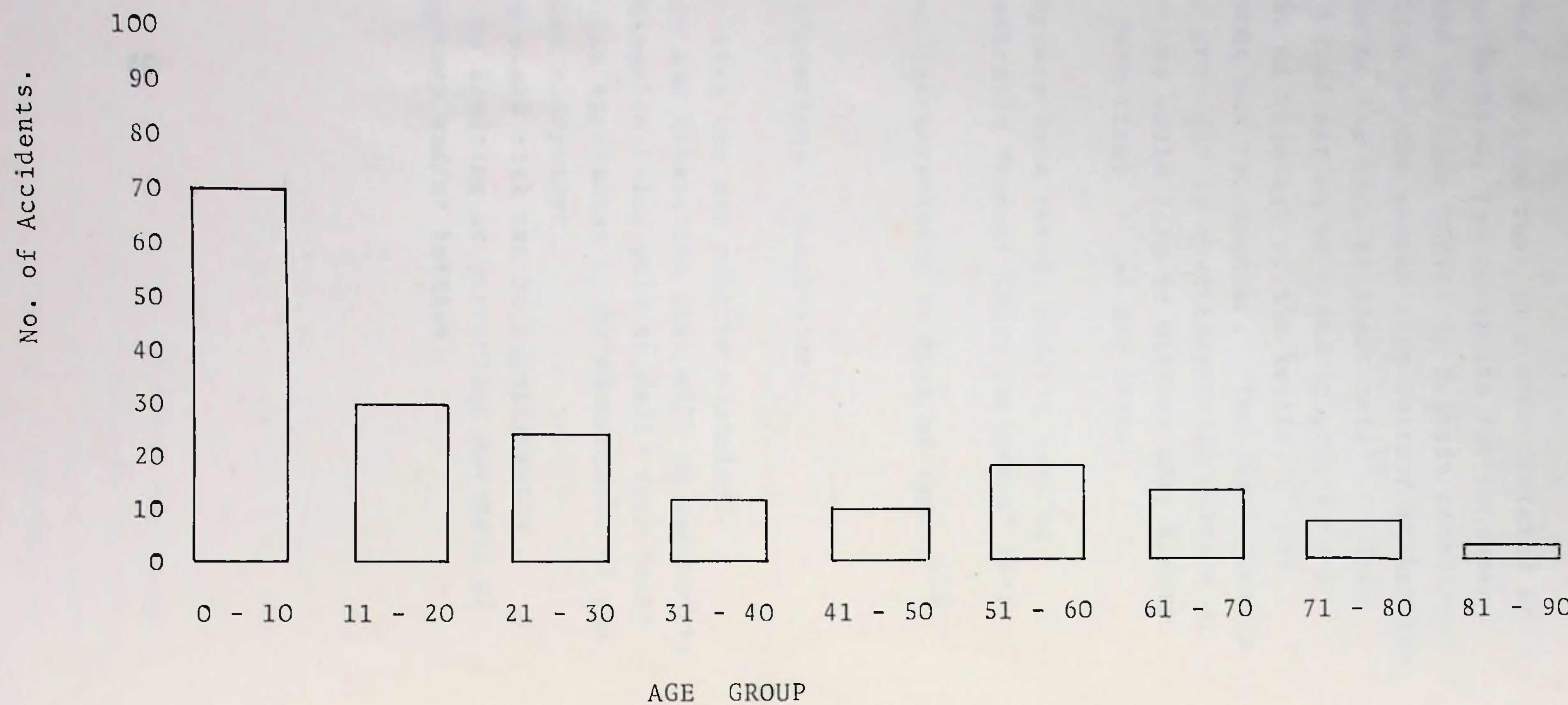


Fig. 7. Distribution by age of a listing of kettle accidents recorded by the Hass for the period 23.10.78 to 6.1.80



N.S. Kirk has recorded that in a study related to the design of kettles, the Institute for Consumer Ergonomics and the Home Office in Britain considered the elimination of the portability feature in kettles as a solution to the high accident rate[14]. This however was ruled out an on economic grounds and concentration on redesign of the kettle in conventional terms was recommended. The justification of "economic grounds" is questionable in matters of safety where one would like to believe that safety really does come first - at any cost.

Kirk and Ridgeway have noted, under a heading entitled "Desirable Product Characteristics" that

> "The Prime characteristic is that of safety"[15].

Safety Considerations - conclusions.

1. Accident risk can and must be minimised.
2. Explosion and inhalation risk will be reduced by great attention being paid to fail - safe features in gas appliances or by abandonment of gas appliances altogether.
3. Burn and scald risk can be significantly reduced by limiting or preventing movement of water heaters and/or kettles.

1.2.4. Water Heating - Marketing Considerations.

So far energy and safety considerations of water heating have been presented independently of marketing aspects which, literature searching has revealed, may be a major determinant in the development of a design solution. Choice of appliances is often made on an entirely subjective basis. In the past safety and energy considerations have not been sales points but every indication is that the buying consumer increasingly armed with data derived from the media, is becoming more aware of product value in terms of running cost, safety to operator, convenience and appearance. Products cannot be considered in isolation from consumer needs and desires, and it is clear that user expectation of product performance is rising.

Marketing aspects of Energy Consumption of Appliances.

In a recent article in Energy Policy, Jørgan Nogard from the Technical University of Denmark presented counter arguments to popular opinions expressed about the unimportance of domestic energy consumption:

1. "The daily electricity consumption of each appliance is insignificant and not worth considering" - not true: in Denmark the domestic sector accounts for about 40 per cent of the electricity consumption and this figure applies also in the U.S. and the U.K.

2. "Consumers are not asking for appliances which save electricity and more frequently, they are not willing to pay a higher price for them" - not true: the payback

for electricity saving design is usually only a few years and in some cases is negligible. If consumers are offered energy-saving appliances, accompanied by proper declarations and information then it will become clear whether they are interested in saving energy.[16]

In the United States Congress has already passed legislation calling on various Federal agencies to establish certain standards for the performance of appliances. As a result of this, a labelling system has been introduced for certain appliances that sets out at the point of sale, a measure of the energy that the appliance requires in normal use and the efficiency with which the energy is used. Thus the buyer can ascertain by comparing labels that the appliance with the lowest retail price may not be the cheapest in the long run because of its large energy requirements or relative inefficiency. Labels on air conditioning units give an energy efficiency ratio (EER) rating at the point of sale. This allows the customer to compare appliances in terms of energy consumed versus energy usefully transferred to do its intended work.[17]

So the conclusion here must be that consumers will, in the future, be very conscious of what they are buying in energy terms. Accordingly, it is reasonable to assume that energy-saving appliances will have a very definite share of the market.

Consumer Demand for Hot Water.

In order to establish the scope of the term 'small quantity' in the context of consumer demand for hot water, it was necessary to study a number of domestic activities involving the use of hot water. Estimates of domestic hot water usage patterns are poorly documented and when they are dealt with, it is difficult to extract information of a precise nature from them. The topic is usually discussed in the very broad terms of a family's typical weekly hot water requirement specified at a single temperature and ranging between 700 and 1200 litres. Since different activities involve a variety of temperatures and quantities it becomes necessary, from the water heater manufacturer's point of view, to know which particular applications he intends his appliance to cater for. The most useful quantitative work seems to have been carried out by the British Electricity Council who have correllated much of the data collected by various government and other official agencies since 1945[18]. These data attempt to set out the typical quantities associated with various hot water applications. The information is made more useful by the inclusion of specified or preferred temperatures for the applications in question. Table 7 illustrates the typical hot water quantities and temperatures for a range of domestic activities.

Bath	Basins for Handwashing	Dishwashing	Floor and Domestic Cleaning	Laundry
114 litres @ 43^{o} C	4.5 litres per usage @ $43^{o}C$	4.5 litres per meal @ $60^{o}C$	4.5 litres per usage @ $60^{o}C$	15 - 45 litres per wash @ $60^{o}C$
73 litres @ $60^{o}C$	3.1 litres @ $60^{o}C$	-	-	-
61 litres @ $70^{o}C$	2.4 litres @ $70^{o}C$	3.7 litres @ $70^{o}C$	3.7 litres @ $70^{o}C$	12.3 - 37.6 litres @ $70^{o}C$

Table 7. Typical Hot Water Requirements.

It can be seen that in three of the above cases, quantities of less than five litres are required at 60°C.

This table does not include water heated for the purposes of preparing drinks. The U.K. Tea Council estimates that the average person in Britain consumes 4.15 cups of tea per day and more than one cup of coffee per day. This means that up to 150 million cups of water are boiled per day. This in itself represents a very sbustantial contribution to energy consumption.[19]

Miscellaneous applications of hot water have not been estimated by anyone to the author's knowledge. Therefore, there are no figures for quantities of water heated for filling hot water bottles, de-icing windscreens in winter, preparing instant foods or carrying out hobbies etc.

The conclusions here are that water heating requirements may be categorised into two groups: quantities not exceeding 4.5 litres and quantities exceeding 15 litres. Water temperature requirements range between 45°C and 100°C but most needs can be catered for by water either at 60°C for domestic purposes or at 100°C for the preparation of hot drinks.

Product Safety.

With changes in civil law probable in the near future in regard to product liability, consumer awareness of product safety will grow. As a consequence, safety as a factor at the point of sale will become a significant selling feature along with appliance efficiency. In their conclusions to a paper entitled 'Ergonomics and Product Liability' Kirk and Wilson have stated:

"Many manufacturers already implement extensive quality assurance procedures in order to identify and eliminate manufacturing defects. It is the identification and elimination of design defects which will most concern them in the future".[20]

Complex Interfaces.

Increased control of appliance performance often demands the introduction of user interfaces that are more complex than had hitherto existed. There is some debate as to the merits of multifunction features and controls being introduced into appliances. It is important to avoid the inclusion of gadgetry for its own sake. It has been shown however that gadgetry alone has sold appliances. Nevertheless effective design aims to last well beyond the point of sale.

The question of gadgetry is not at issue here so much as whether or not, given a valid use for complex controls appliance users can cope with them. Current trends in many consumer products would seem to indicate that there is a growing demand for multifunction interfaces. Stereo systems, Televisions, Automatic Washing Machines, etc., all operate via controls which users adapt to quite readily. The approach of the full computer age, introducing children at school to complex keyboards and abstract machine instructions will ensure that user adaptability to complex interfaces will not be a significant problem.

Product Appearance.

In a consumer report by Appliance Manufacturer U.S.A.,, it was show that at the point of purchase of an appliance, the husband is usually more intersted in how a product works and the wife in how it looks[21]. The same report claims that in kitchen appliances, more than half the decisions to buy are made by women. Included in product appearance are factors such as colour, shape, size, cleanability and compatibility with intended environment.

A survey carried out in 1979 by the National Housewares Manufacturers Association of the U.S.A. into the attitudes and purchase habits of consumers of housewares products has indicated that the preferred treatment of surface finishes for kitchen appliances was "Stainless Steel and Metallic Tones"[22]. Most respondents to the survey showed that they try to coordinate the colour of housewares items with their kitchen or bathroom colours.

Neither report attempted to quantify how consumers rated features such as cleanability, ease of maintenance or compatibility with intended environment (other than in terms of colour). It appears that feedback data of a detailed nature about products is simply not available.

Marketing Considerations - Conclusions.

1. There is a market for efficient appliances.
2. There is a market for a water heating appliance catering for the quantity range 0-4.5 litres, and temperature range 45° - 100°C.
3. Product Safety is becoming a sales point.
4. Complex Interfaces can and are being coped with and used to beneficial effect by users.
5. Product appearance rates high in choice of appliance.

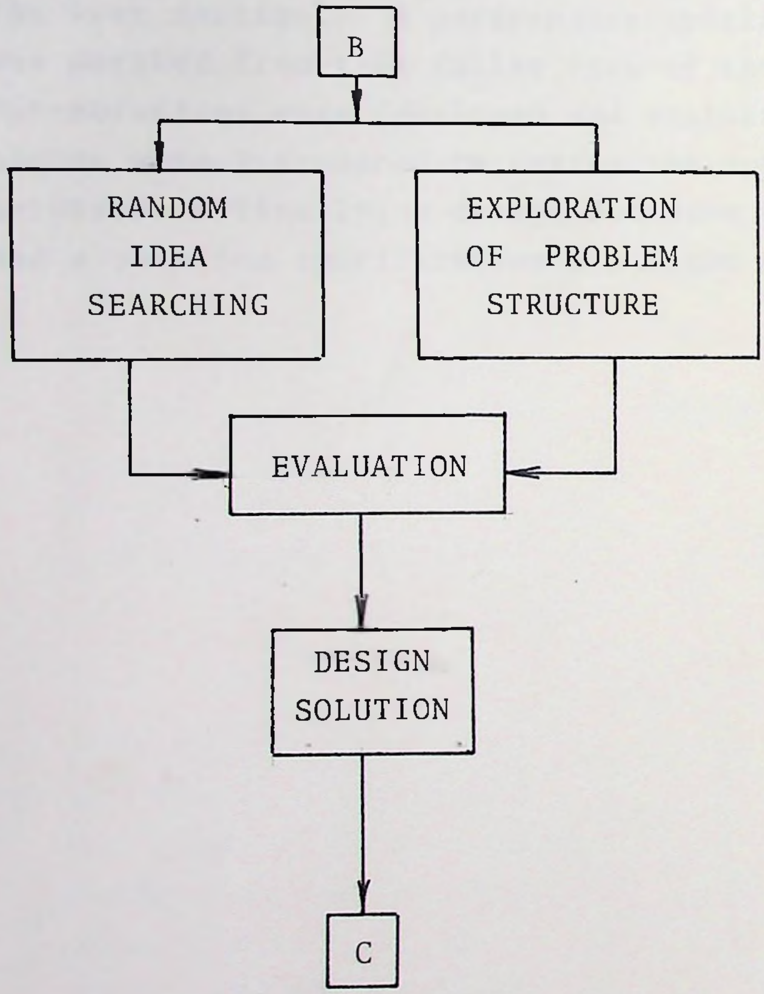
1.2.5. Summary of Critical Parameters.

The critical parameters operating in any design solution that may be adopted will be:

SAFETY TO OPERATOR
WORKING EFFICIENCY
MARKETABILITY
MANUFACTURABILITY.

It goes without saying that cost is the overall determinant but safety is considered to be of prime importance. A problem will be to decide on an "acceptable level" of safety, i.e., one where risk is minimal and cost factors don't render the product unproduceable. The other factors will suffer trade-offs against one another in an effort to blend costs and manufacturing processes with consumer appeal in terms of efficiency and convenience as well as appearance.

SECTION 2. DESIGN PHASE



2.1. Introduction.

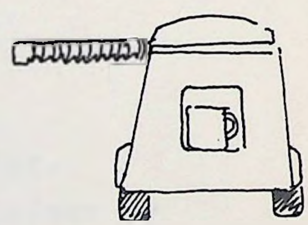
The Design Phase of this project was conducted in two ways. Firstly, in order to avoid polarisation of approach, random idea searching was carried out in the form of spontaneous sketching and writing of thoughts. Morphological Charting was used to increase the idea space. Secondly, when these resources had been tapped, a more formal approach to exploration of problem structure was adopted. This was applied to the random ideas generated, and the data conclusions arrived at in the last section. A performance specification was derived from this fuller view of the problem. Sub-solutions were developed and evaluation techniques were introduced to derive the optimum solution. Finally, a design decision was made and a solution specification was drawn up.

2.2. Random Idea Searching.

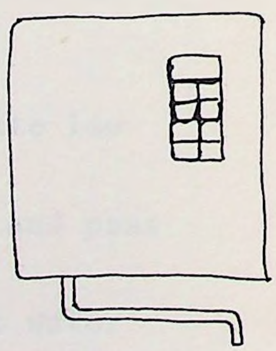
2.2.1. Spontaneous sketching and writing out of thoughts. Words and drawings were used extensively to build up concepts dissociated from practical water heating limitations. One of the most useful exercises in this process involved an attempt to define the extreme ideal solution to water heating problems. Five descriptions were listed in order of approach from the ideal to the real.

1. This water heater is the water heater of my imagination. It heats the water for the needs of my imagination. I don't feel dirty, thirsty or cold.

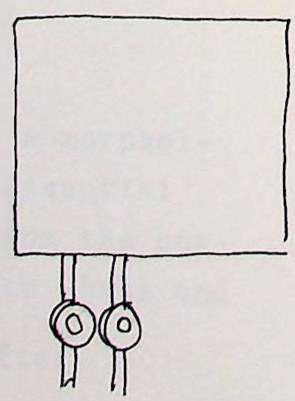
2. This water heater knows me well. It anticipates my every need precisely, always ahead of demand and brings my requirement to me.



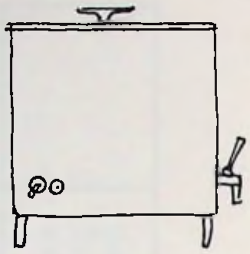
3. This water heater knows my regular requirements but needs to be told about exceptions and seasonal adjustments. It is smart, but has no initiative.



4. This water heater has to be told what I want every time I want it.



5. This water heater is helpless. I have to fill it, wait, empty it. It can even turn nasty.



Another useful exercise involved the random listing of ways in which water could be heated.

- Leave water in black container in sunshine.
- Light fire around container of water.
- Put water container around fire.
- Drop hot material into water.
- Pass water over hot material.
- React water with chemical to produce unaffected but hot water.
- Use cooling systems to heat water.
- Vibrate water using radio waves.
- Burn gas in vicinity of water.
- Burn oil in vicinity of water.
- Use geothermally heated water.
- Burn solid fuel in vicinity of water.
- Use electricity to heat water container by induction.
- Use electricity to heat water by contact with element.
- Burn sawdust around water container.
- Use heat pump to extract and concentrate low thermal energy.
- Use wind power to drive friction pads and pass water through.
- Use internal combustion engine to heat water while doing work.

2.2.2. Morphological Chart.

These ideas were processed further in a morphological chart by listing them against essential functions of a water heater derived from the conclusions of the subsections of the Data Phase and the critical parameters listed thereafter.

Function	Sub-Solution								
Provide Heat Source	Solid Fuel	Liquide Fuel	Gas	Electric Induction	Electric Resistance	Chemical Reaction	Friction	Solar Radiation	Microwave
Container Water	Metal Tank	Plastic Tank	Ceramic Tank	Glass Tank	Metal Tube	Plastic Tube	Heating Jacket	Heat Water in-situ	
Minimise scald and Burn Risk	Limit Portability	Cut out Portability	Isolate Heating Chamber	Porthole Exit Only	Vent Steam Away	Insulate Pipe Exit	Push to Pour Tap	Never heat water above $40^{o}C$	Fix Unit to Wall
Control Water Temperature	Always Boil	Timer Switch	Thermometer	Guess Temperature	Thermal Switch	Temperature Sensitive Paints	Variable Thermostat	Fix temperature	
Control Water Volume	Use Graduated tank	Pre-measure water	Have level indicator	Use flow water	Use dip stick	Use weighing system	Automatic Selection of level	Fix Amount	
Increase Efficiency.	Insulate Tank	Insulate Tubes	Recycle Waste Gases	Speed Up Heating Cycle	Force Convection	Polish Inside of Tank	Programme Selection System	Minimise Boiling Duration	

Table 8. Morphological Chart.

Heat Source	Small Quantity Capability	Transport of Fuel	Operational Cleanliness	Safety	Cost	Efficiency	Temperature Capability
Liquid Fuel	Poor	Necessary	Poor	Low Risk	Medium	Poor	Good
Solid Fuel	Poor	Necessary	Poor	Low Risk	Medium	Poor	Good
Gas	Good	Unnecessary	Poor	High Risk	Medium	Good	Good
Electric Induction	Good	Unnecessary	Good	Unknown	High	Unknown	Good
Electric Resistance	Good	Unnecessary	Good	Low Risk	High	Good	Good
Chemical Reaction	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown	Unknown
Friction	Good	Unnecessary	Good	Unknown	Unknown	Unknown	Unknown
Solar Radiation	Good	Unnecessary	Good	Low Risk	Low	Unknown	Poor
Microwave	Good	Unnecessary	Good	High Risk	High	Unknown	Good

Table 9. Feasibility of Heat Source Options.

2.3. Feasibility.

By tabulating the various options generated in the morphological chart, it was possible to assess the merits of each main sub-solution against operating circumstances that might obtain during normal use (Table 9)

It was found that the electrical resistance method satisfied every condition admirably - with the exception of running cost which could be higher than other methods. It was decided, however, in view of the possibilities for increasing efficiency that the electric option could be cost effective and moreover would have several significant advantages over all the others.

For certain sub-solutions the entry "unknown" has been made. This designation was reached once preliminary data had indicated that the particular sub-solution would require research and development which would be beyond the scope of this project.

2.4. The Electric Option.

The electric option was further considered using the AIDA (Analysis of Interconnected Decision Areas) method as described by Jones 1970[23]. The purpose of this method is to identify and to evaluate all the compatible sets of sub-solutions to a design problem - in this case, the design of an electric water heater.

2.4.1. Identification of Feasible Options in Each Decision Area.

The major decision areas in designing an electric water heater based on data presented earlier on were considered to be:

Heat Transfer	-	how to transfer the heat to the water.
Safety	-	how to minimise scald and burn risk.
Quantity Control	-	how to control amount of water.
Temperature Control	-	how to control temperature of water.
Heat Loss	-	how to minimise losses.
Energy Input	-	how to minimise electrical load.

The following feasible options proposed in each decision area are shown in table overleaf.

Decision Area	Option 1	Option 2
Heat Transfer	a1 Instantaneous Heater	a2 Storage Heater
Safety	b1 Sealed portable Container	b2 Fixed Unit
Quantity Control	c1 Level detector	c2 Flow Meter
Temperature Control	d1 Thermostat	d2 Regulator
Heat Loss	e1 Insulation	e2 Heat Quickly
Energy Input	f1 Minimise Element Rating	f2 Use several Elements.

Table 10. Decision areas and Options.

2.4.2. Inter Compatibility of Options.

Using an Inter-action matrix all options were considered (Table 11).

OPTIONS 1 = Compatible 0 = Incompatible		a1	a2	b1	b2	c1	c2	d1	d2	e1	e2	f1	f2
Instantaneous Heater	a1			0	1	0	1	1	1	0	1	0	1
Storage Heater	a2			1	1	1	0	1	1	1	1	1	1
Sealed Portable Container	b1					1	0	1	1	1	1	1	1
Fixed Unit	b2					1	1	1	1	1	1	1	1
Level Detector	c1							1	1	1	1	1	1
Flow Meter	c2							1	1	1	1	1	1
Thermostat	d1									1	1	1	1
Regulator	d2									1	1	1	1
Insulation	e1											1	1
Heat Quickly	e2											0	1
Minimise Element Rating	f1												
Use Several Elements	f2												

Table 11. Interaction Matrix.

The reasons for the assumed incompatibilities in the matrix are as follows:

b1a1 Instantaneous System must be a flow system.
c1a1 There can be no level detection in a flow system.
c2b1 Flow meter does not indicate level in storage system.
c1a1 Insulation may have a negative effect in instantaneous system.
f1a1 Instantaneous systems require high element rating.
f2c2 Cannot heat quickly with low element rating.
c2a2 Flow meter does not indicate level in storage system.

There were 29 remaining feasible combinations. However, several other criteria existed with which these combinations had to contend. These are contained in the performance specification derived from the foregoing explorations of problem structure and from data analysed previously.

2.4.3. Performance Specification.

The Water heating appliance must:

a. be capable of providing boiling water.
b. be capable of delivering water at a selected temperature.
c. be capable of delivering a specified quantity of hot water.
d. have an element rating not exceeding 3 KW.
e. at least equal an electric kettle in boiling time.
f. be permanently fixed to a wall or work surface.
g. display the level of water contained or flowing.
h. be cool to the touch.
i. signal when temperature is reached.
j. warn user when temperature of water is above scald temperature.

k. vent steam away from user.
l. have built-in safety cut out switches if electrical overload occurs.
m. have minimum and maximum level cut-outs if a tank is used.

Point (a) above ruled out an instantaneous system on the grounds that boiling in a flow system is problematic, potentially hazardous and losses can occur in run off of water before the temperature required is attained. Point(f) ruled out portability for safety reasons. Point (d) ruled out an instantaneous system also, because boiling would be achieved only with difficulty in an instantaneous system with anything less than 5KW rating. Point (b) suggested that regulation of element input current would not be sufficiently responsive to achieve a good degree of accuracy. The use of several elements was also ruled out - this time on a cost basis.

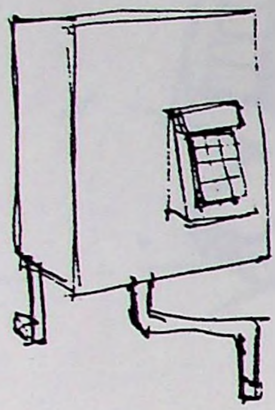
The following compatible set of options appeared to offer the most beneficial design solution:

a2b2c1d1e1f1

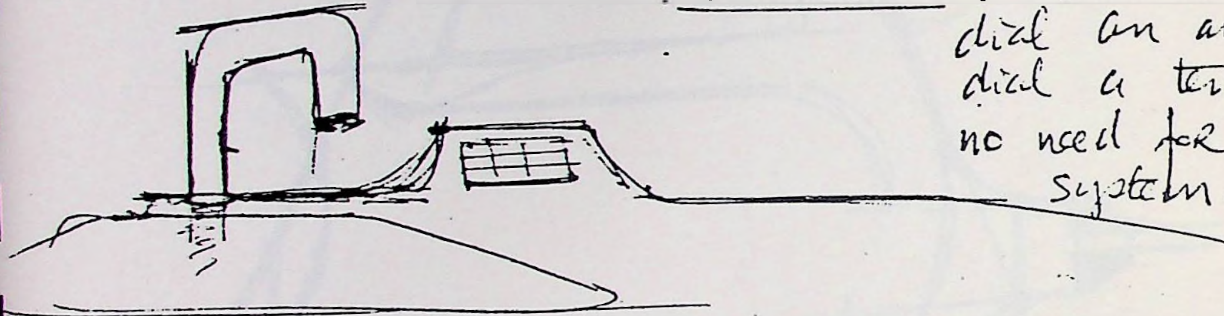
That is: A storage water heater fixed to a wall or work surface with an automatic level selection system and temperature selection system. The unit would be plumbed in and encased so as to contain the tank and the control system, separate from each other and both isolated from the user.

At this point, it was considered appropriate to conceptualise as much as possible around the performance specification. A series of sketches were produced. These are reproduced in the following pages. A number of sketches carried out prior to the arrival at the present performance specification are also included here. Some three dimensional models of a four-litre volume were constructed in polystyrene to explore the shape possibilities. It was realised that quite a flat shape could be achieved and two sketches based on this discovery represented a major conceptual design decision.

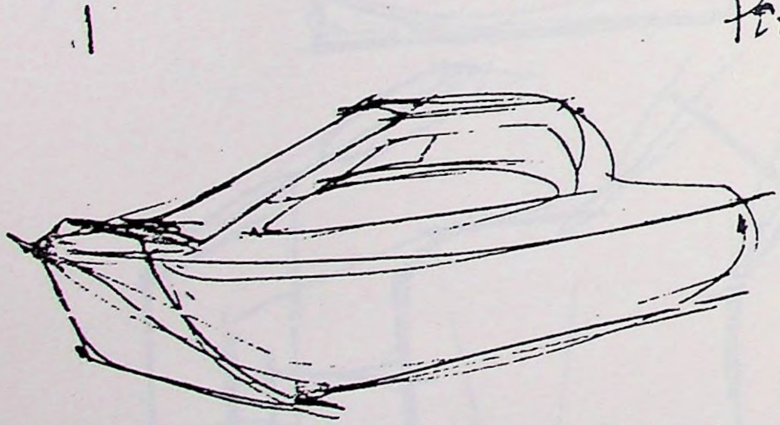
Finally, a presentation drawing was produced. This drawing was based on the data and design decisions considered and attempted to project an impression of what the actual appliance would look like.

1. 

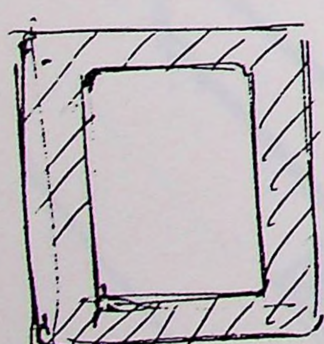
TANK: Plumbed in, dial an amount
dial a temperature
no waste self control system.
possible dual tank —
interim storage.

2. 

Instantaneous. Plumbed-in
dial an amount
dial a temperature.
no need for interim
system.

3. 

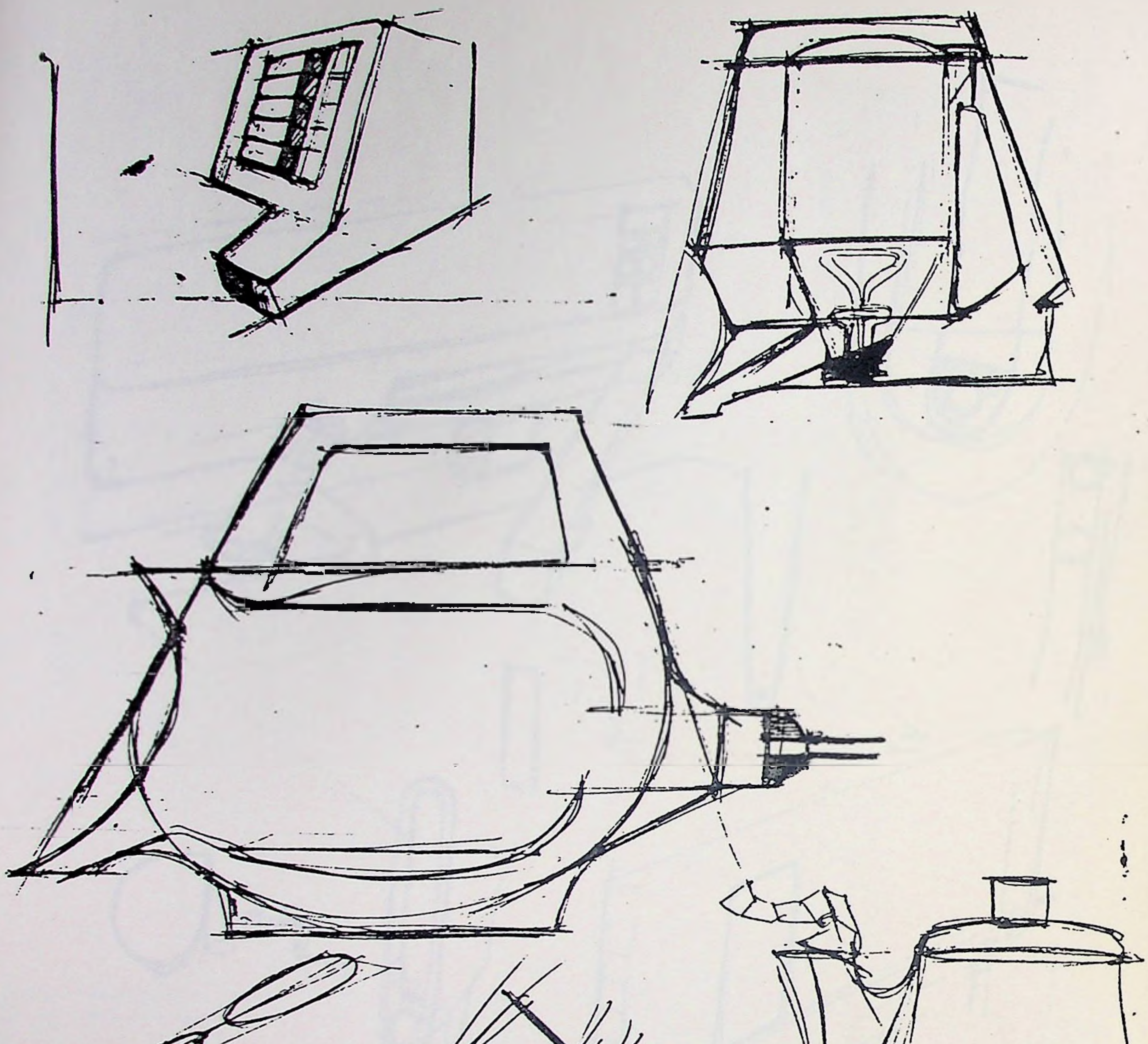
Portable: sealed, leak-proof
when inverted or dropped
etc. accurate amount +
temp. control. heavy
insulation.
Possible low voltage supplement
-ary element to boost
temp. away from power
source — eg. car battery.

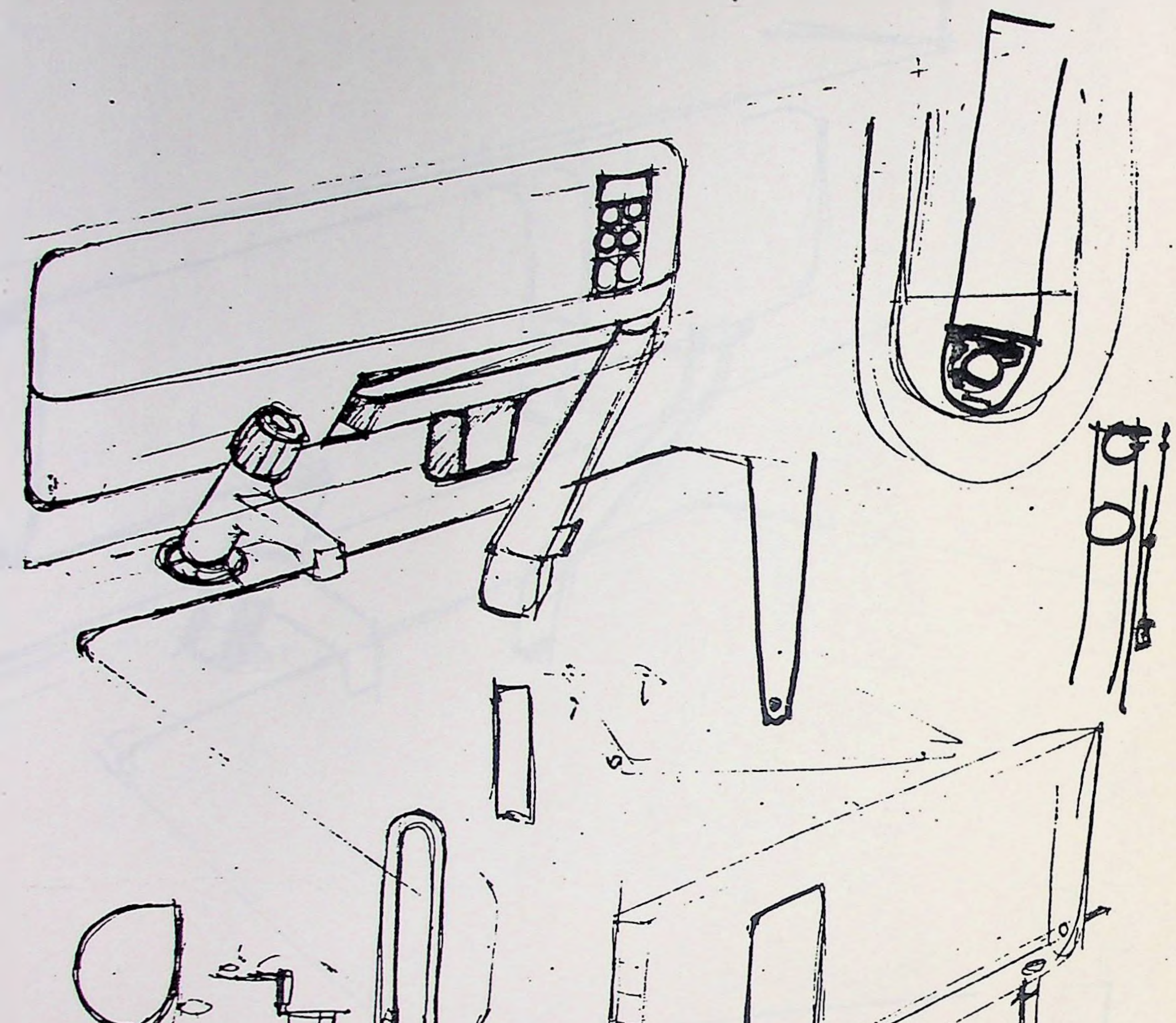
4. 

Very low current long term heater
using mini amt. electricity, gas — etc.

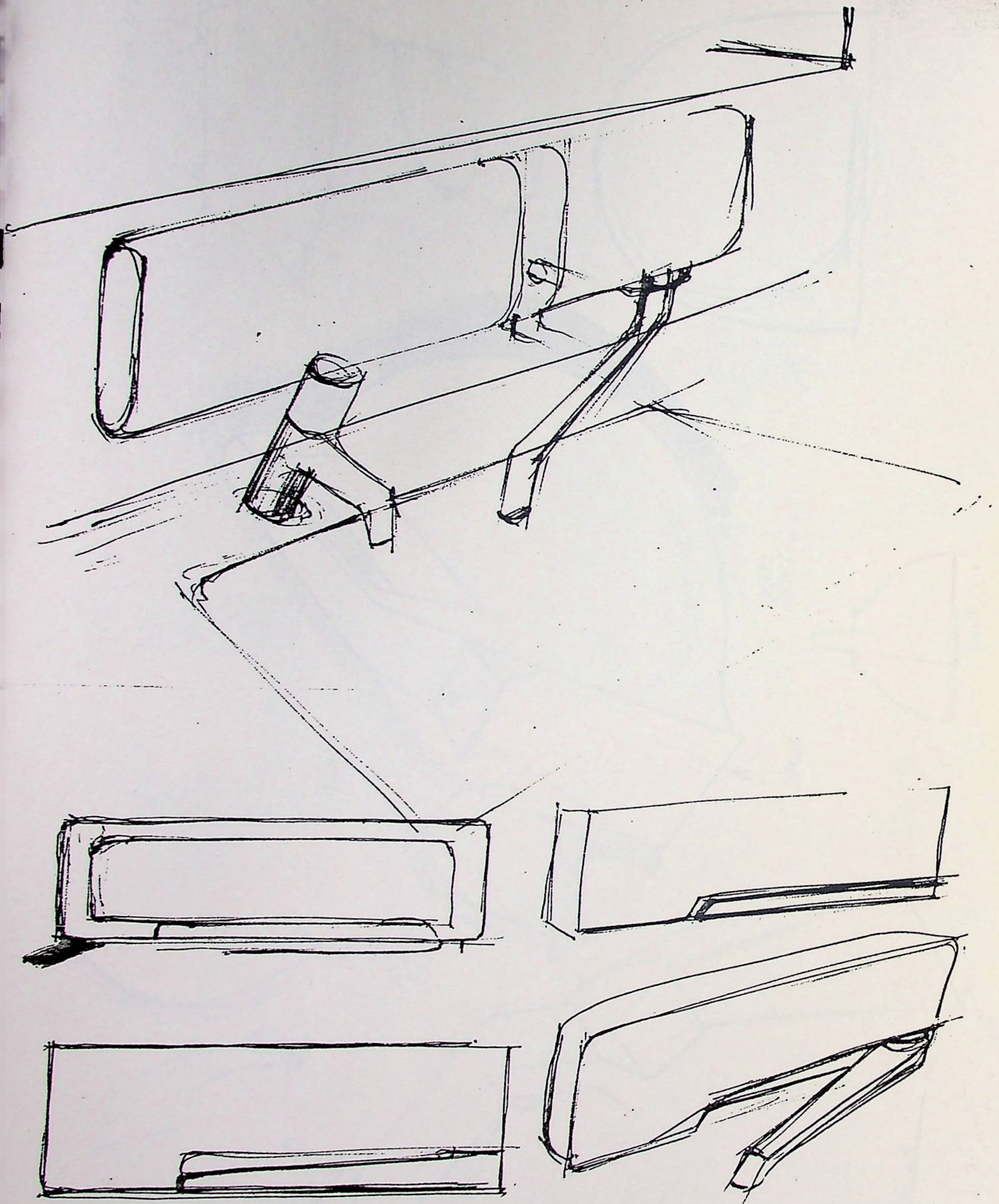
PK Jan 28/81

Plate 1





Feb. 16/81



PK Jan 30/81

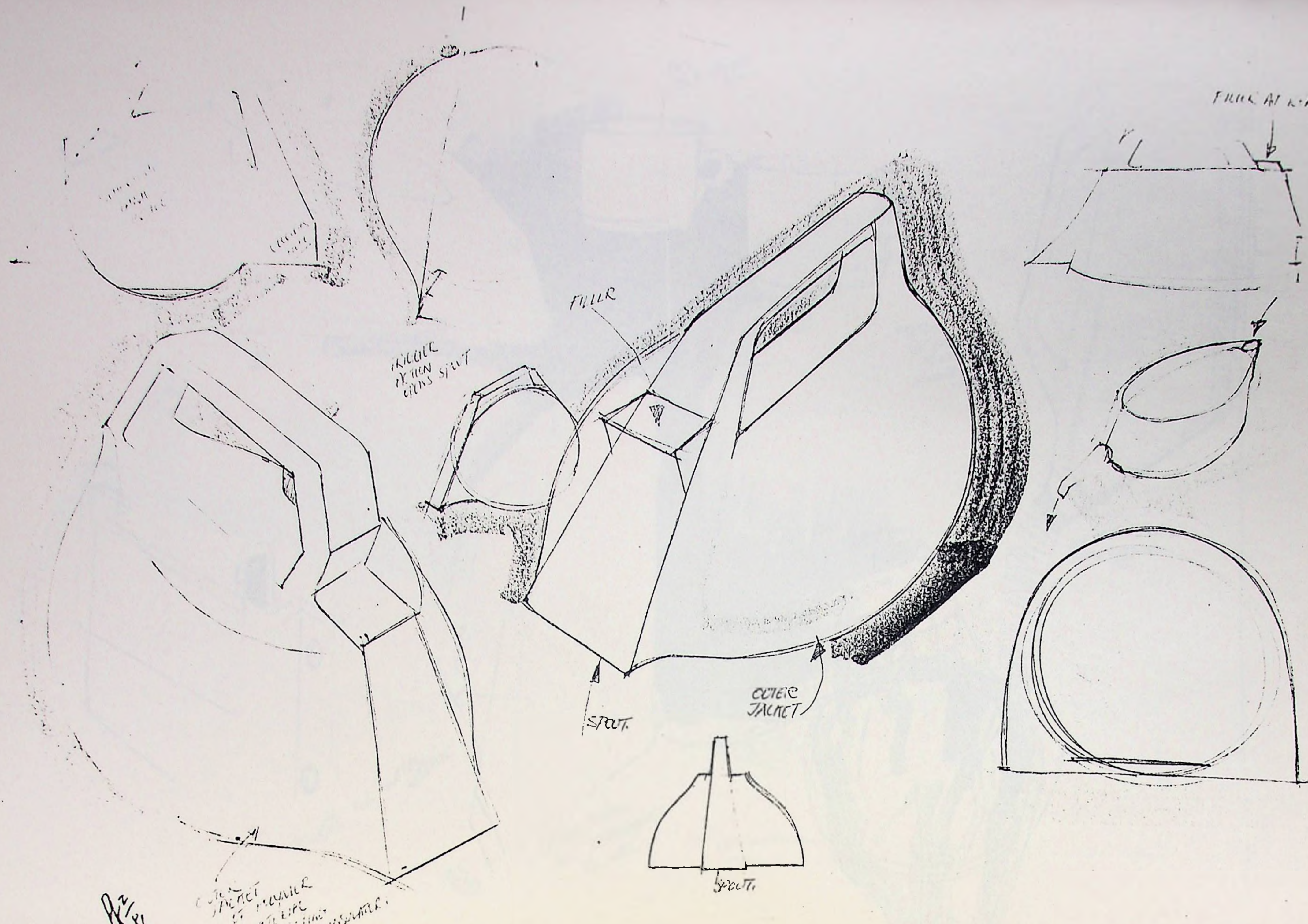


Plate 5. Roughs - Kettle Configuration

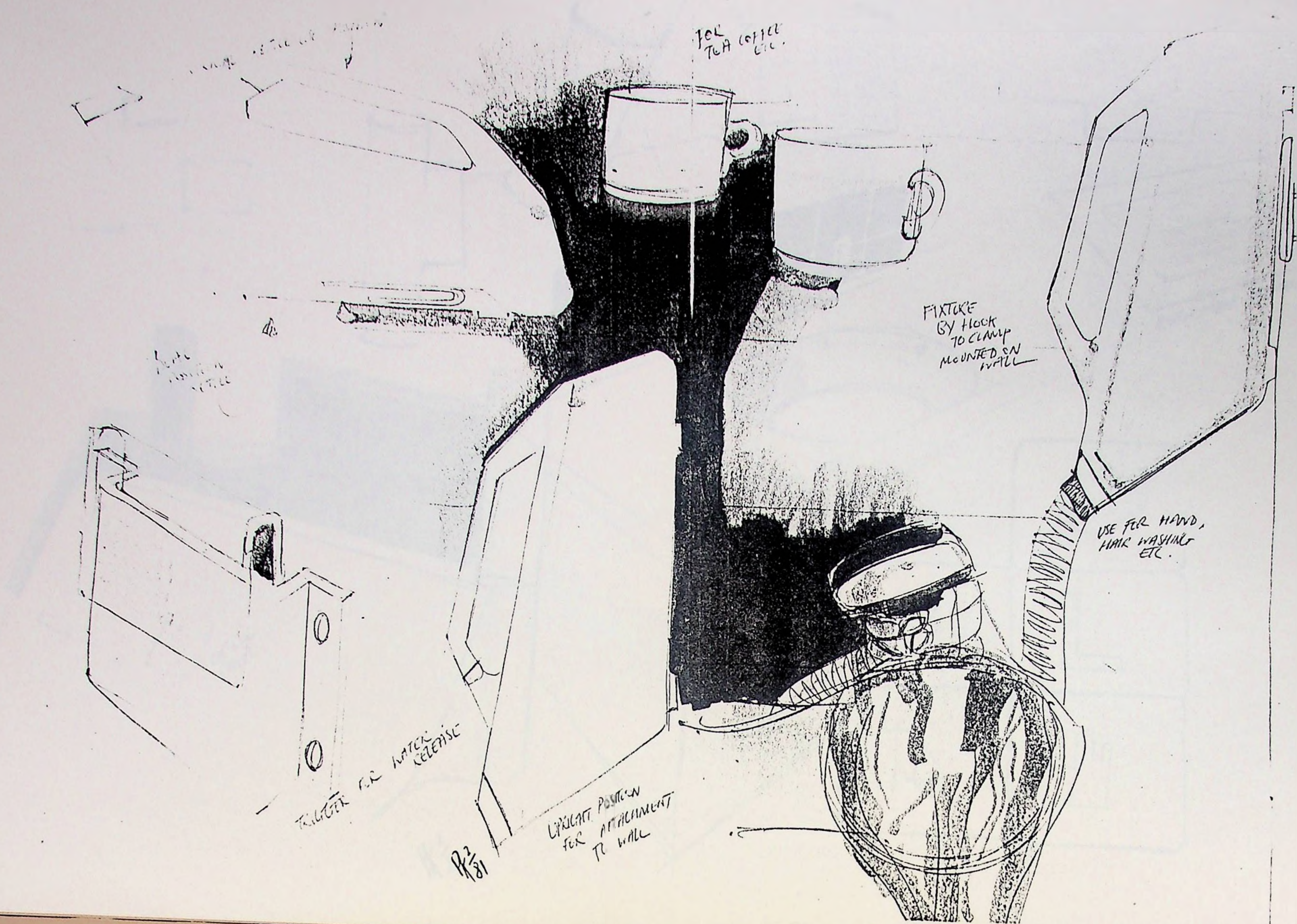


Plate 6. Roughs - Kettle Configuration

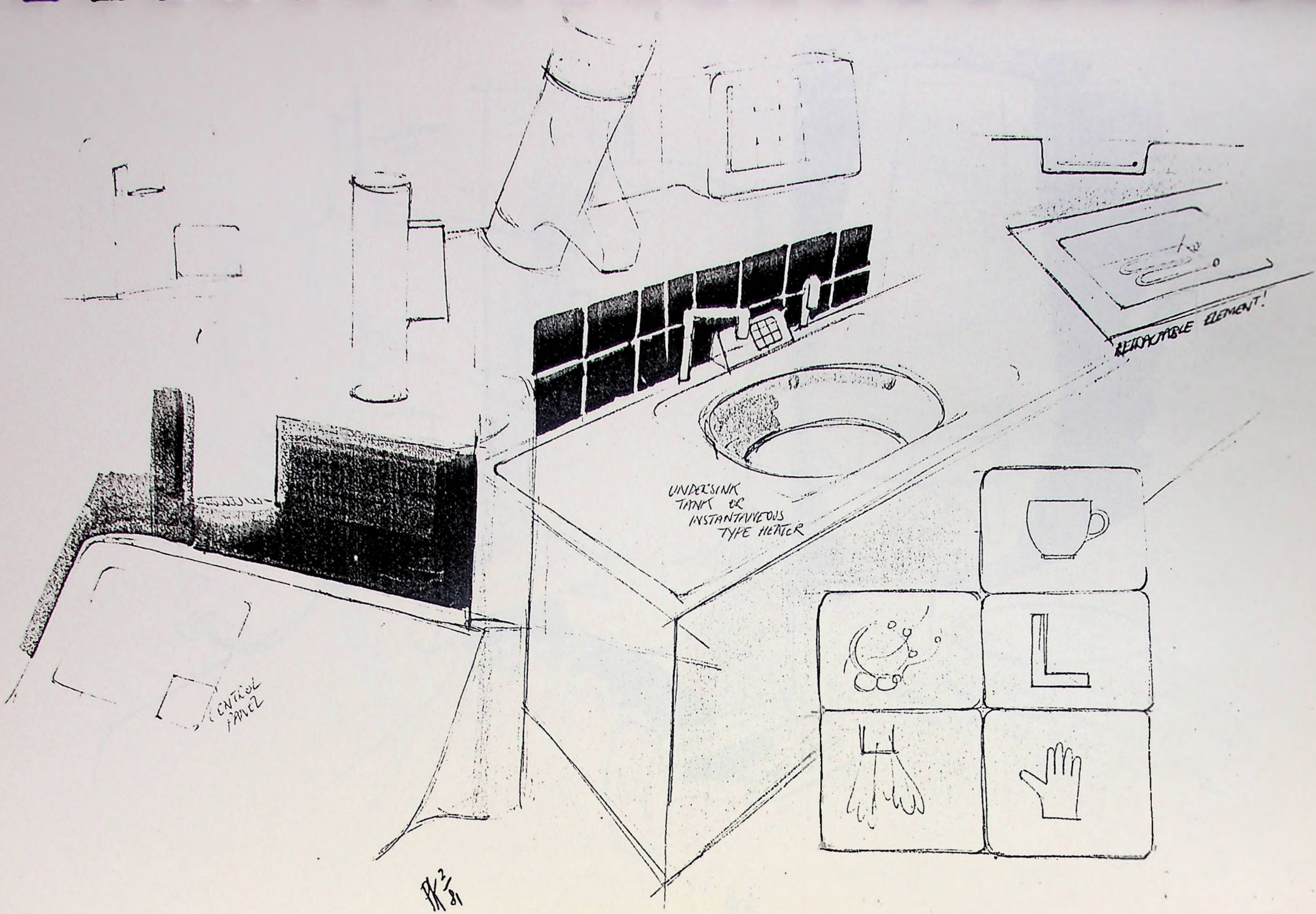


Plate 7. Roughs - Integrated Sink Water Heater

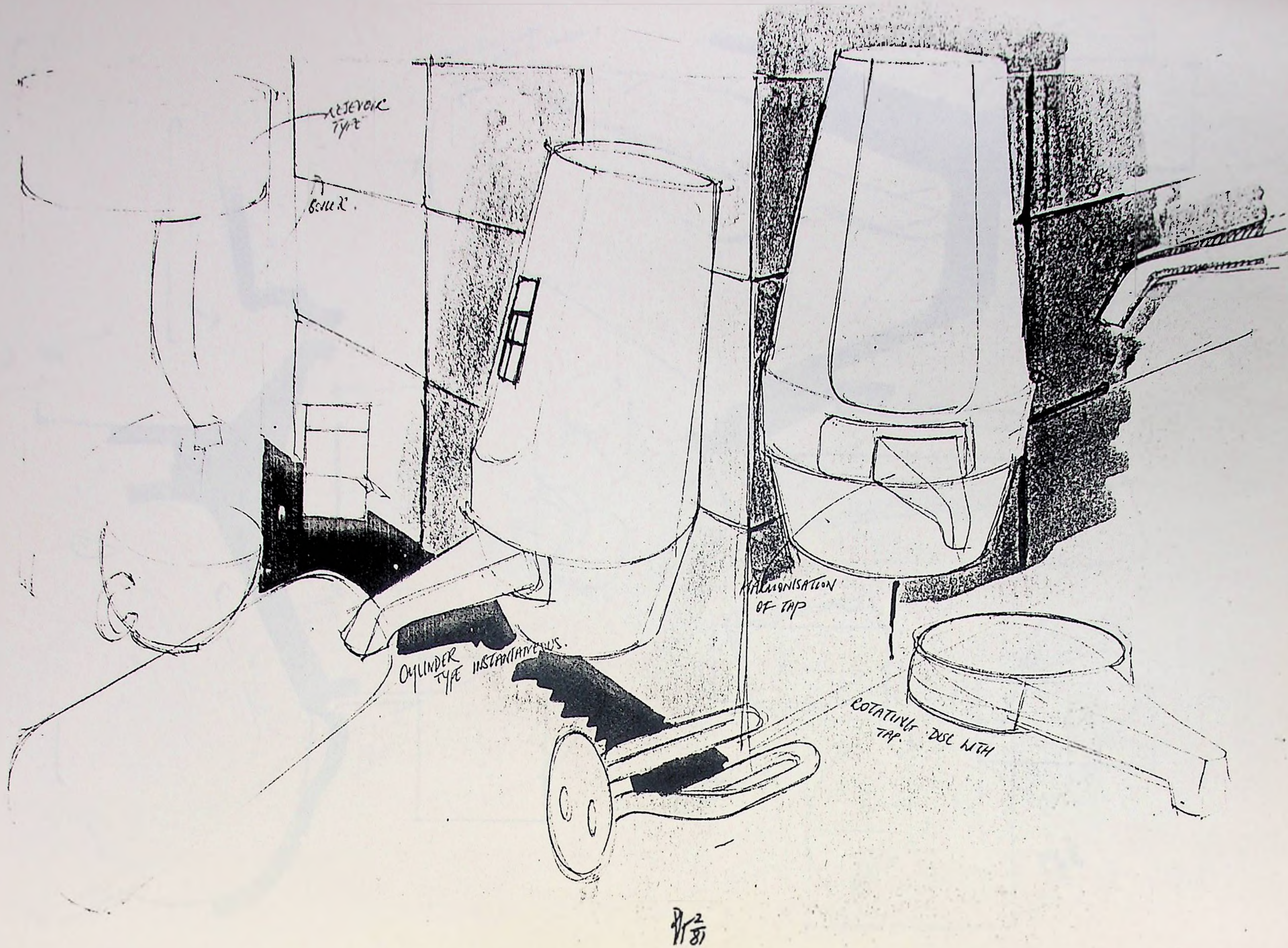


Plate 8 - Roughs - Water Heater Possibilities.

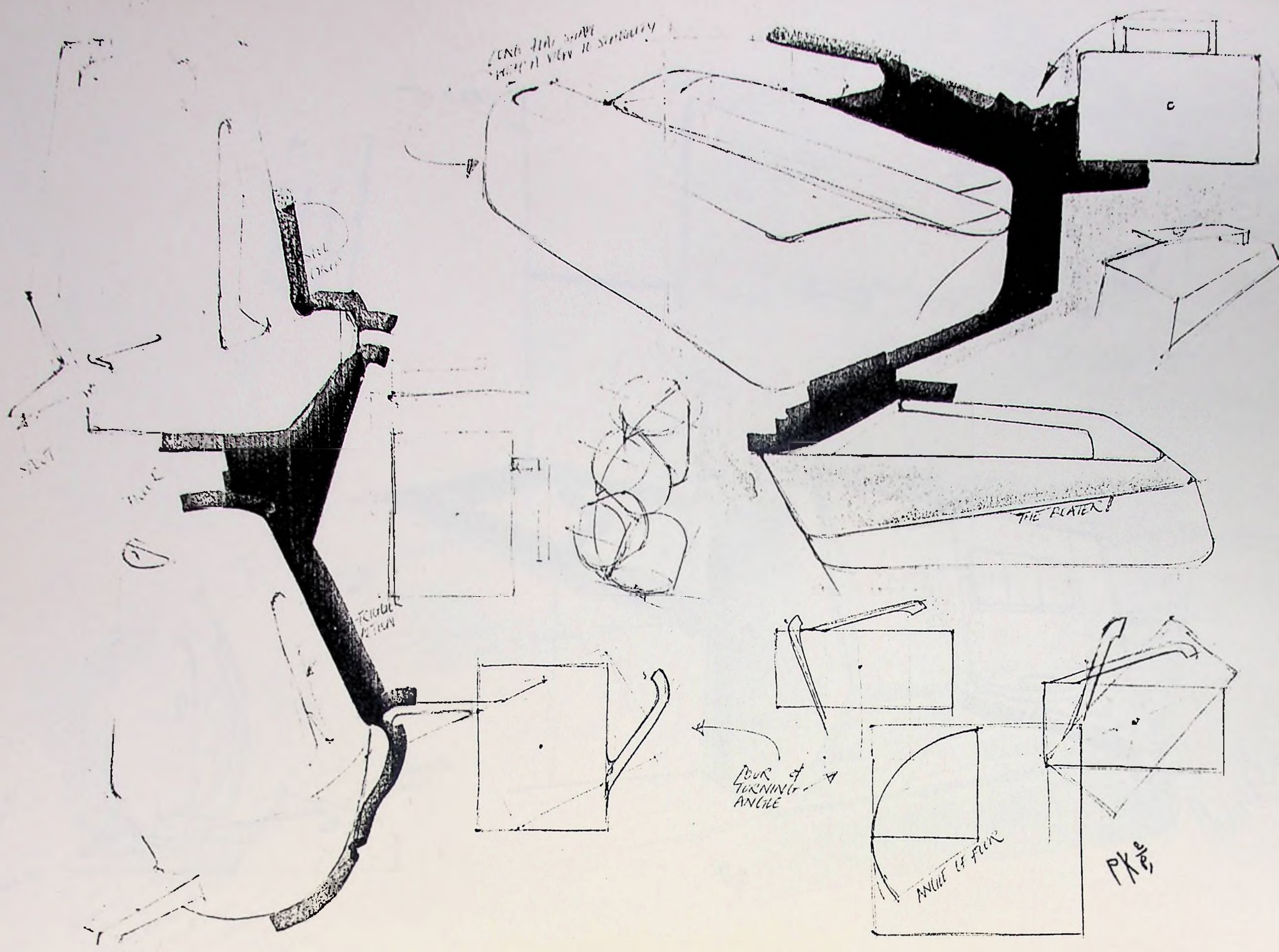


Plate 9. Roughs - Kettle Configurations.

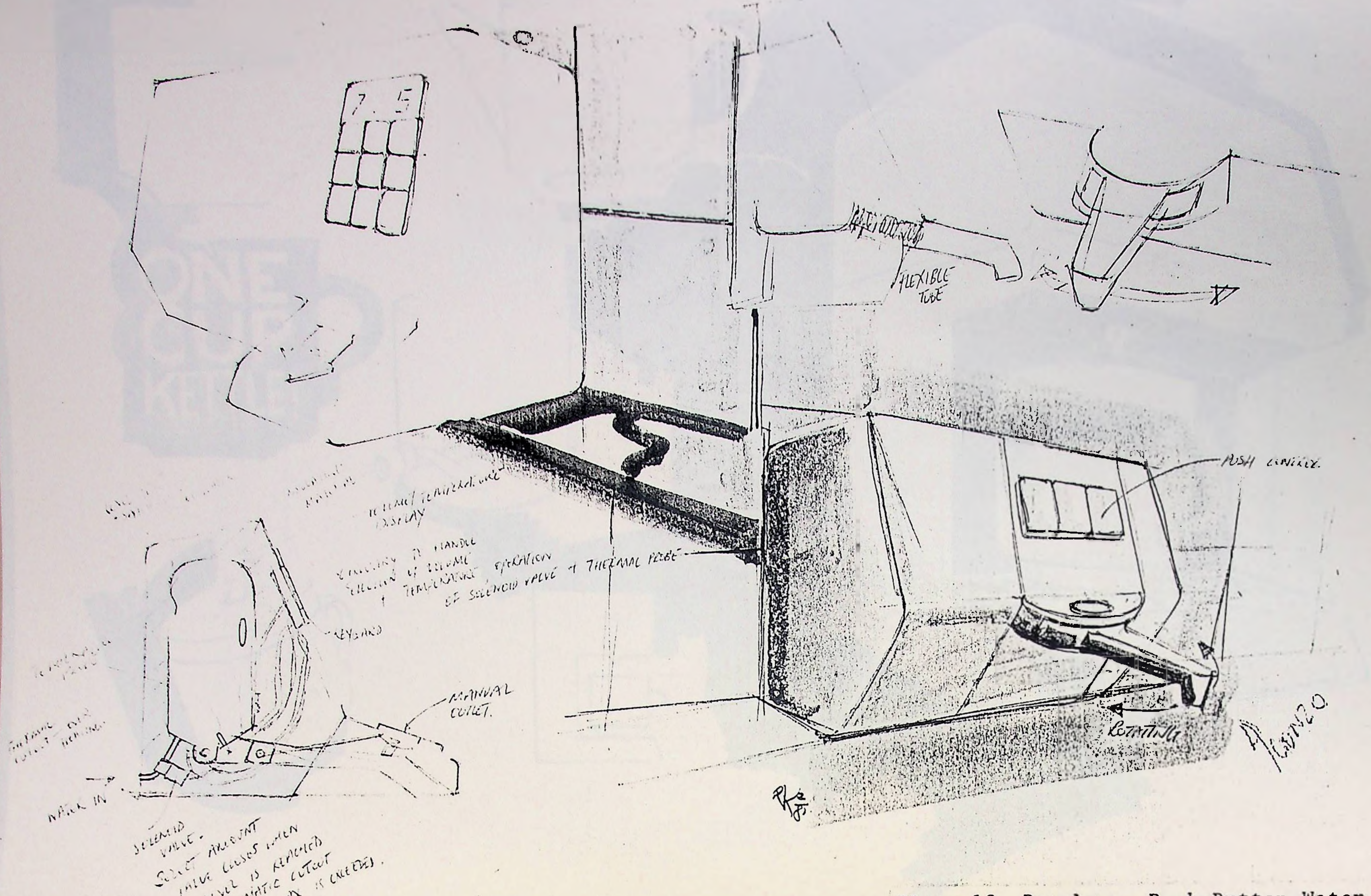


Plate 10. Roughs - Push Button Water Heate

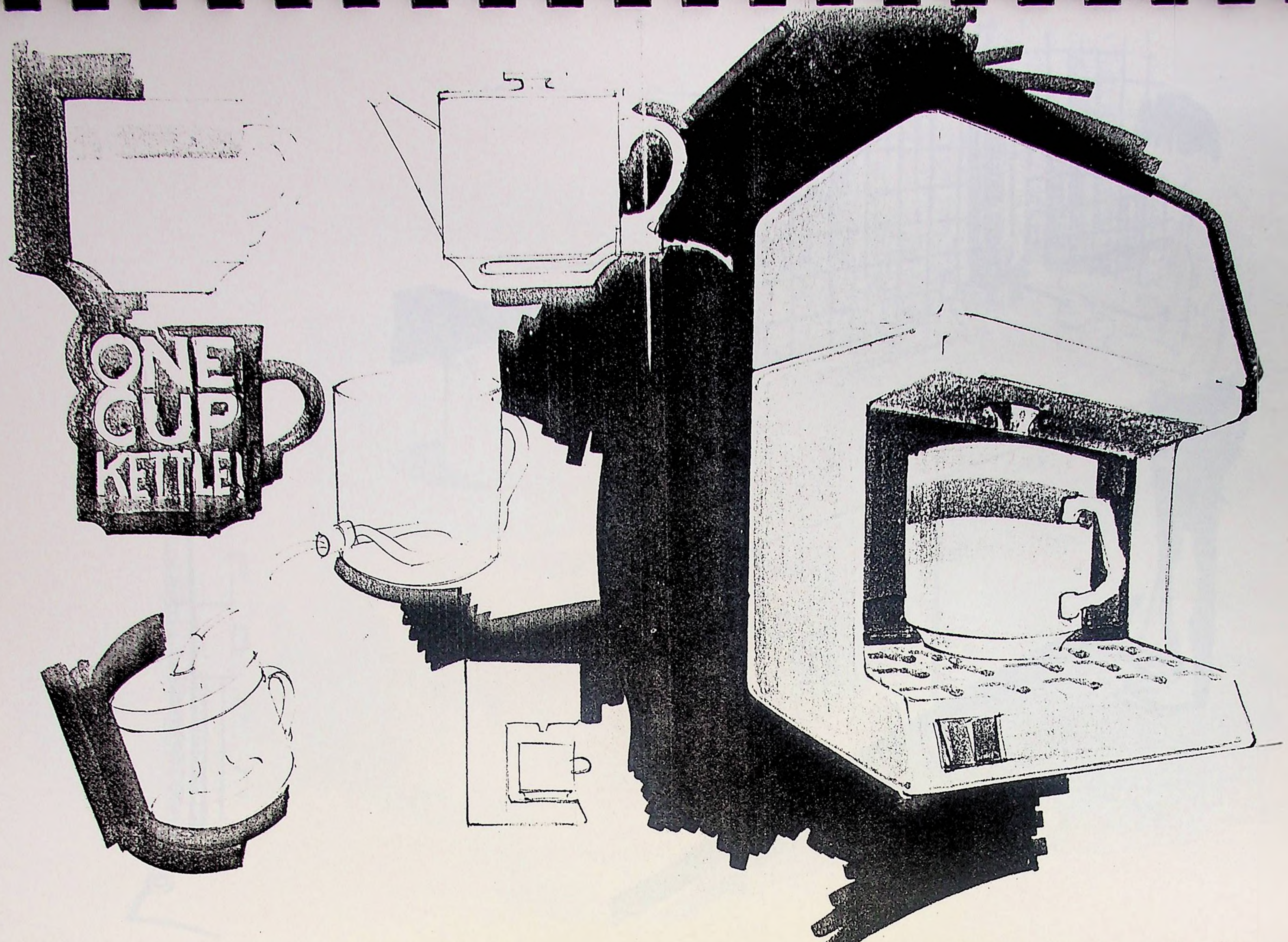
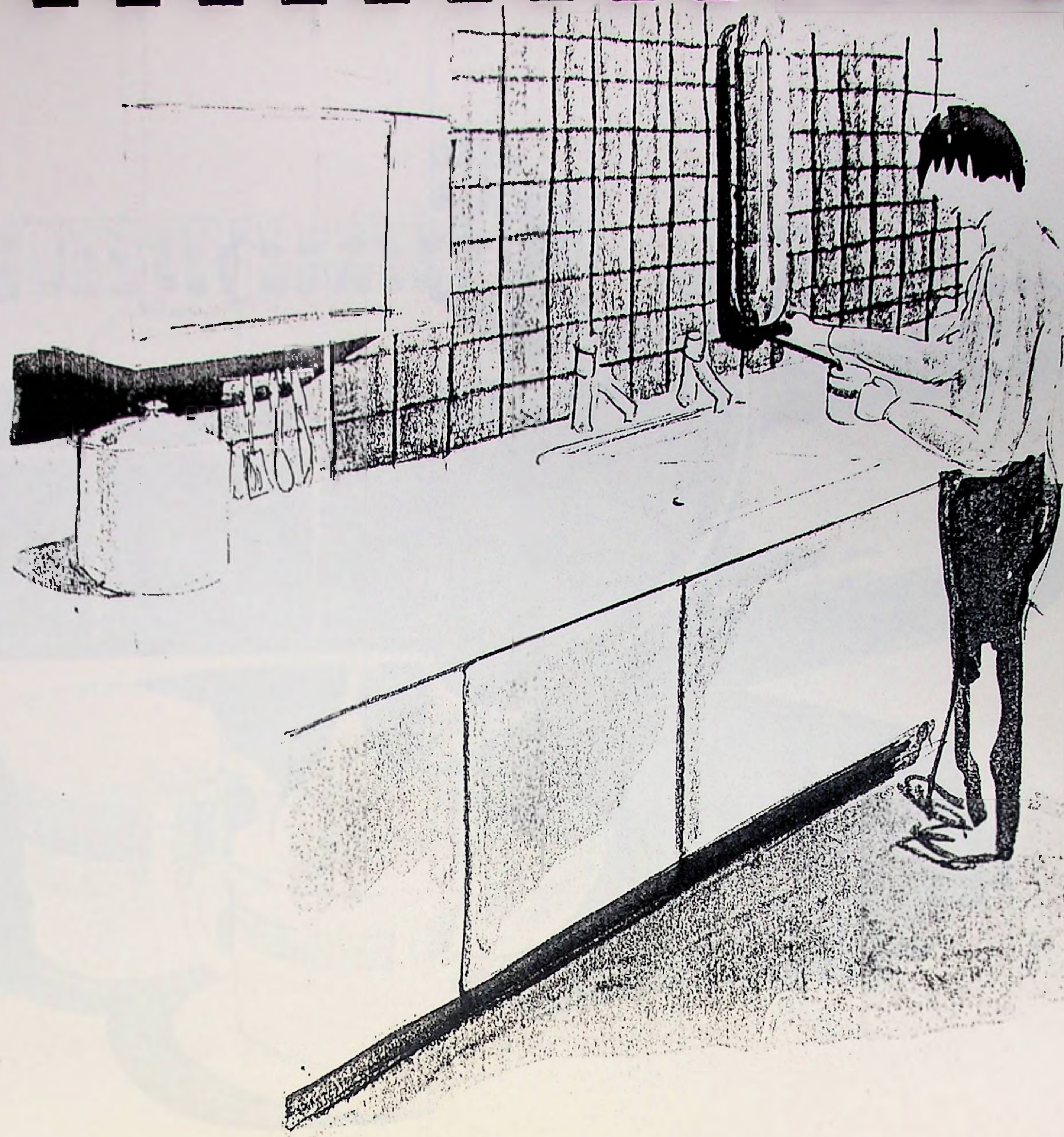


Plate 11. Roughs - One Cup Kettle



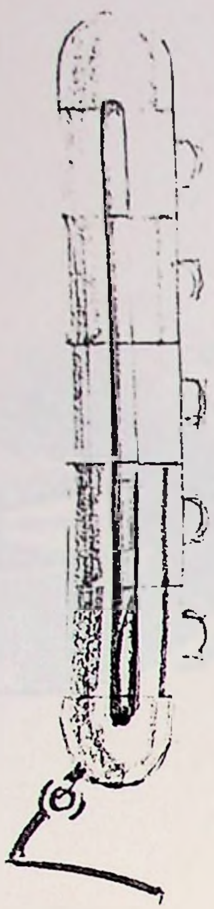


Plate 12. Roughs - "Cup" Kettle.

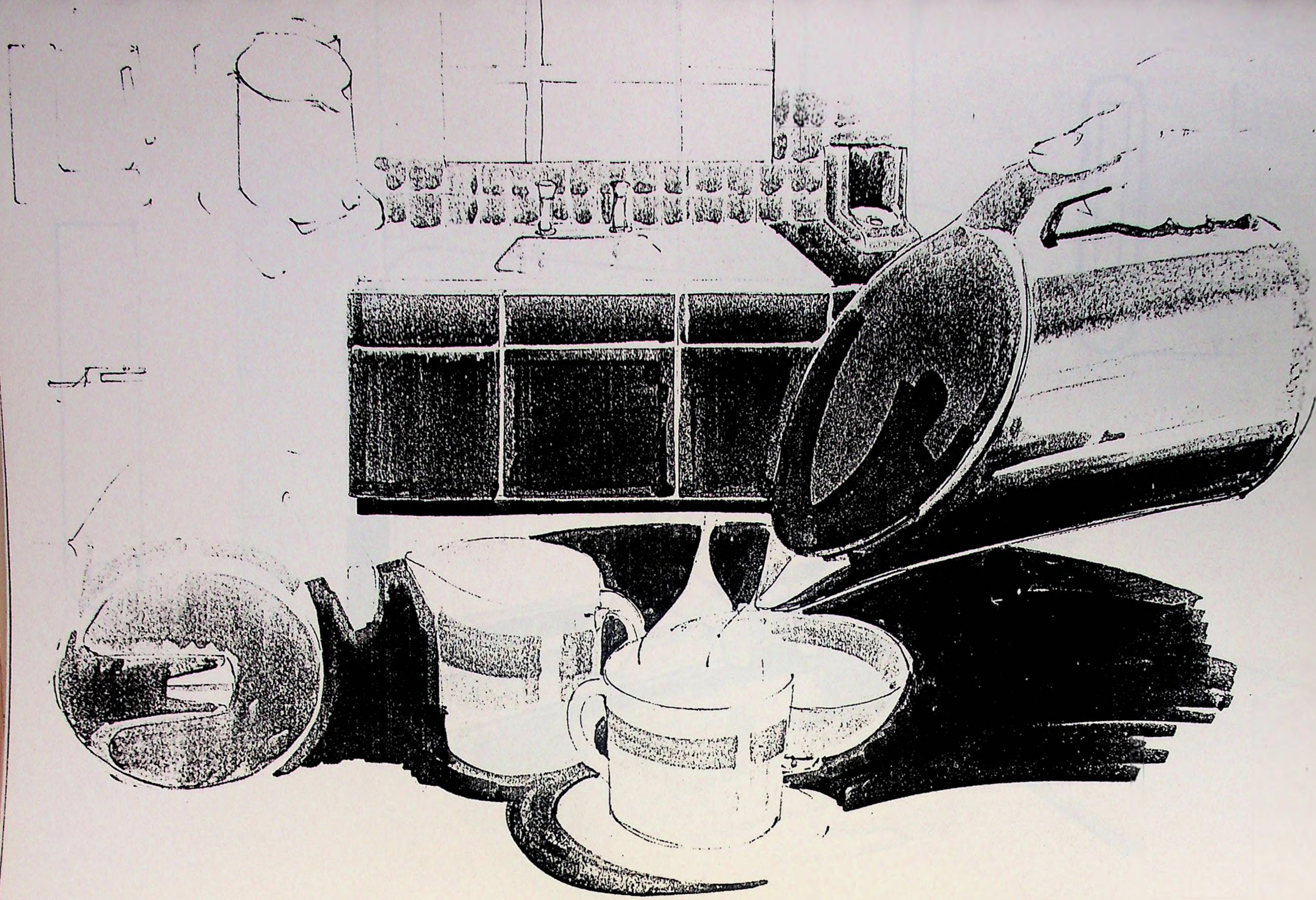


Plate 13. Roughs - Stock Held Kettle.

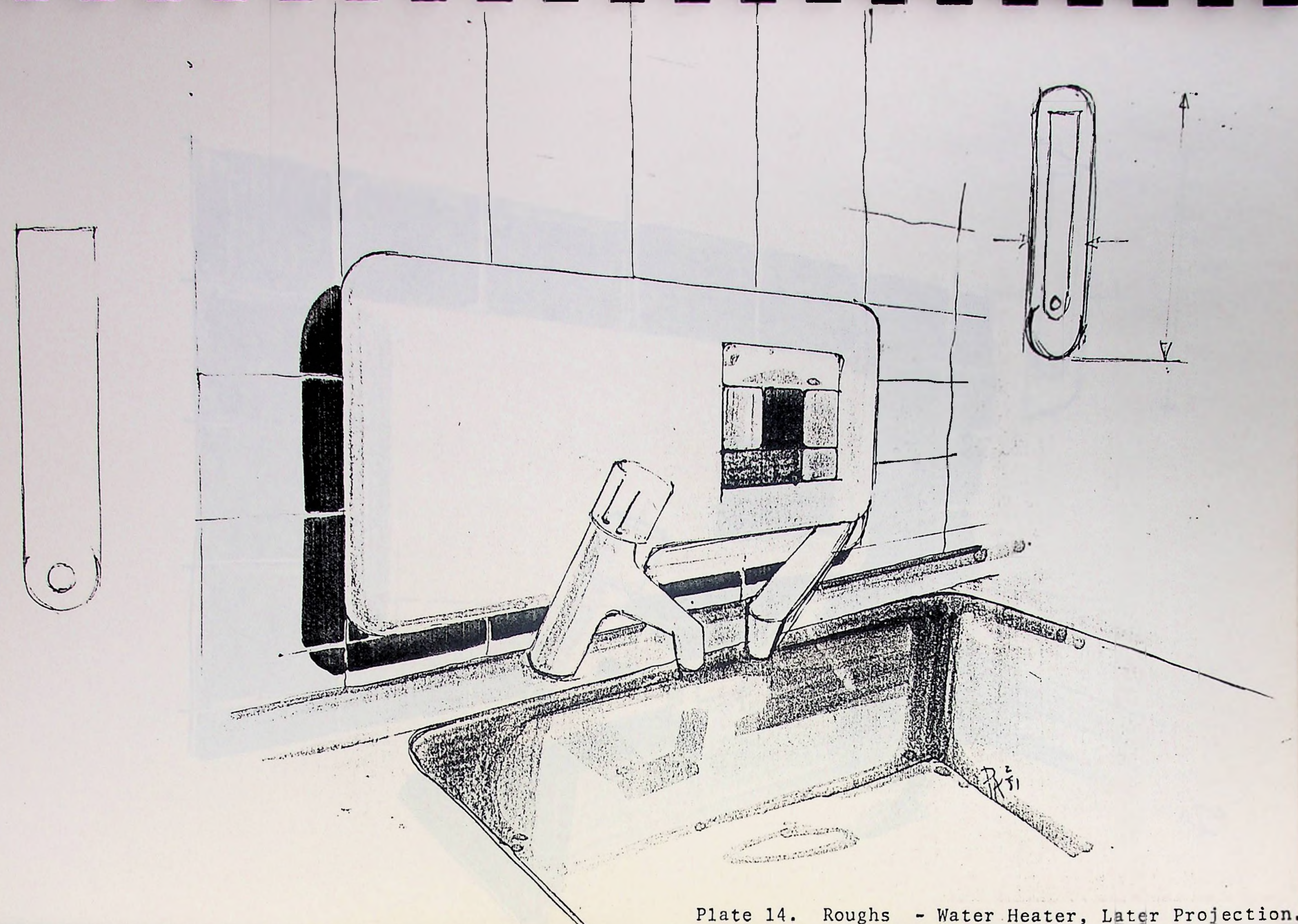


Plate 14. Roughs - Water Heater, Later Projection.

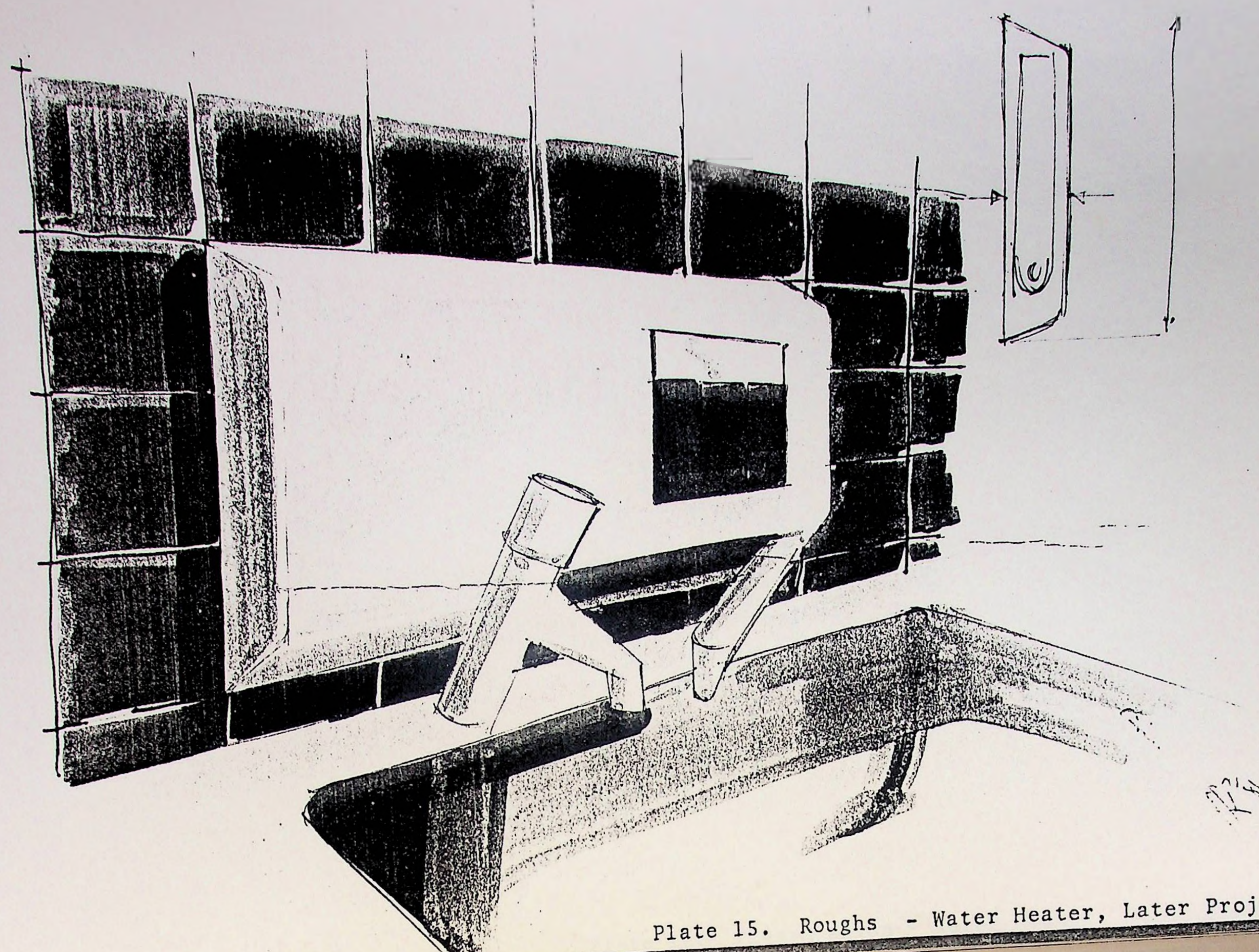
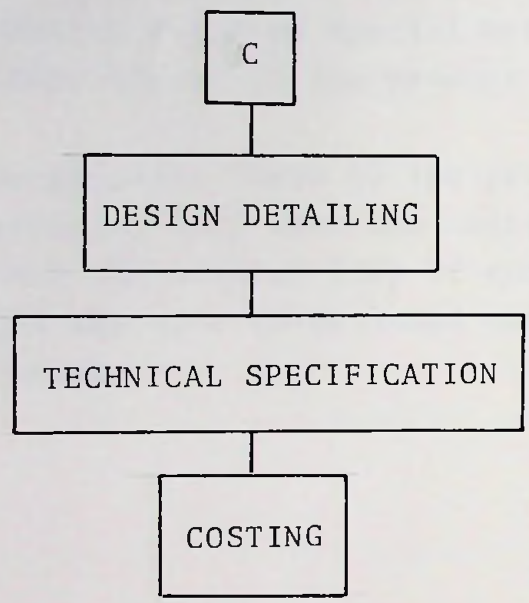


Plate 15. Roughs - Water Heater, Later Projection.

Plate 16. Presentation - Water Heater, Final Projection.

SECTION 3

DEVELOPMENT PHASE



3.1. Introduction.

The Development Phase of the project concerned itself with detail design of the product. It was essentially a continuation of the design phase. The difference lay in the change from broad conceptual designing to detailed hardware designing. Work began with the water tank and control system as these would largely determine the appliance overall dimensions. With these details under study, it was possible to start on the external details of the unit. The switchblock required special attention and was the final aspect of the product to be detailed.

The Development Phase of the project proceeded successfully only with the retrieval of much data and the availability of much help from experts who were interviewed constantly as problems arose.

3.2. Tank Specification.

Development began with the container within which water was to be heated. Decisions had to be taken regarding its dimensions. These were determined by:

- 4.0 litre maximum capacity
- 0.5 litre above maximum capacity for boiling clearance.
- 0.2 litre minimum capacity.
- Element configuration.
- Level detection system.
- Maximum permissable stand-off distance from wall.
- Location of valves and other peripherals.

Initially, minimum capacity of 0.2 litre was considered very important. Great difficulties were encountered in trying to achieve this, however. The first tank constructed used a small coiled element in a recessed 'cup' at one end of the tank. Localised boiling occurred and the far end of the tank never reached boiling point.

The second tank constructed used an element provided by Ideal Ltd. Ideal Ltd., manufacture kettle elements and agreed to supply one in partially manufactured form, i.e. with a single U-bend. It was found that this could be located at the base of the tank and was easily covered by 0.5 litre of water.

Choice of material presented several options. Copper is the traditional material for hot water storage. Stainless steels have become popular in recent years for some electric kettles and boilers. Lately, plastics have come into use in kettles but there is a potential fire hazard here. Ceramic materials have also been used for kettles and hot water tanks. Some problems arise however, in the variation in co-efficient of thermal expansion of metal plumbing fittings and surrounding ceramic units resulting in cracks in the ceramic material when heating occurs.

There was also the question of heat loss to the container and the use of insulation to reduce heat loss to the environment. Insulation would have the added bonus of isolating the hot chamber surface from the user and from the outer casing, in the event that a low temperature stability material was used.

It was decided to remain with copper as the material for the tank. Tank would be fabricated from 22 guage copper sheet and soldered with high tin content solder. Preliminary dimensions were set at 50 x 400 x 200 mm giving a capacity of exactly 4 litres. These, however, were changed by a process of evolution to 62.5 x 365 x 210 mm giving a volume of 4.790 litre and allowing 35mm above the maximum water line for boiling clearance.

It was felt that the tank should be accessible for descaling in hard water areas. The provision of an openable top presents a potential condensation problem which would be unacceptable. The alternative - a factory sealed unit would require that a complete descaling service be available from the manufacturer. The former solution was chosen but difficulties were encountered in achieving a satisfactory seal.

3.3. Control System

The concept of the control of water volume and temperature had to be transformed into a physical reality. Several methods were considered. The first and most simple was to use a graduated transparent level glass in the tank. This is a feature of several appliances already on the market. It was felt, however, that this method was still open to arbitrary usage. A more rigorous approach demanding that the user preselect his quantity and temperature was needed. Automatic volume and temperature selection were explored.

Several methods of detecting level were entertained. These included: the measurement of change in capacitance between two plates partially submerged in the water tank; the measurement in change of voltage across a twin plate resistor submerged in the water; the use of multiple switches at different levels in the tank; the use of a float to change the voltage across a variable resistor. The final option was adopted. This system is presently used for the detection of the level of petroleum in the fuel tanks of motor vehicles. Change in the level of petrol causes a corresponding change in voltage across a potentiometer. This voltage change is used to operate the fuel guage needle on a vehicle's dashboard. In the present case, the voltage change was used to switch a solenoid valve. The user sets up a voltage level at one input of a comparator by pressing a button marked with the quantity he requires. This comparator is fed with another voltage from the float-potentiometer. When the voltage error at the inputs is equal to zero, it means that the level in the tank is the level required. If there is a voltage difference, then the level is either too high or too low. If the level is too low, then the comparator outputs a signal to a solenoid valve to open and water enters the chamber under mains pressure. If the level is too high, then the user may read the display which records the amount of water in the tank at any time. By depressing an 'evacuate' switch, he can observe the water draining off to the required level. This system, of course, requires a second solenoid valve. This option was chosen for safety reasons. The evacuate switch is a 'push-to-make' type switch so that in the event of a spillage, the user disengages the flow of water by simply letting go of the push button.

The voltage at the potentiometer was tapped to supply the display. The potentiometer however, being an analogue device required than an analogue to digital conversion circuit be included. It was hoped also that the heating element minimum level cut out switch would be operated by the float but it was felt that for safety reasons a separate float switch would be required. The temperature selection was limited to two distinct temperature levels i.e. boiling (100^{o}C) and 60^{o}C. These temperatures were selected on the basis of the Electricity Council Data tabulated in Section 1. Two bimetal switches are employed to do the work and according as one temperature is selected, the other switch is latched out. The final piece of circuitry necessary was a power supply to provide a range of voltages -220 volts for the heater and solenoid valves, + 5 volts for the A to D and ancillary circuits and + 15 volts to - 15 volts for the comparator circuit.

A simplified block diagram of the circuitry is shown in Fig 8. .

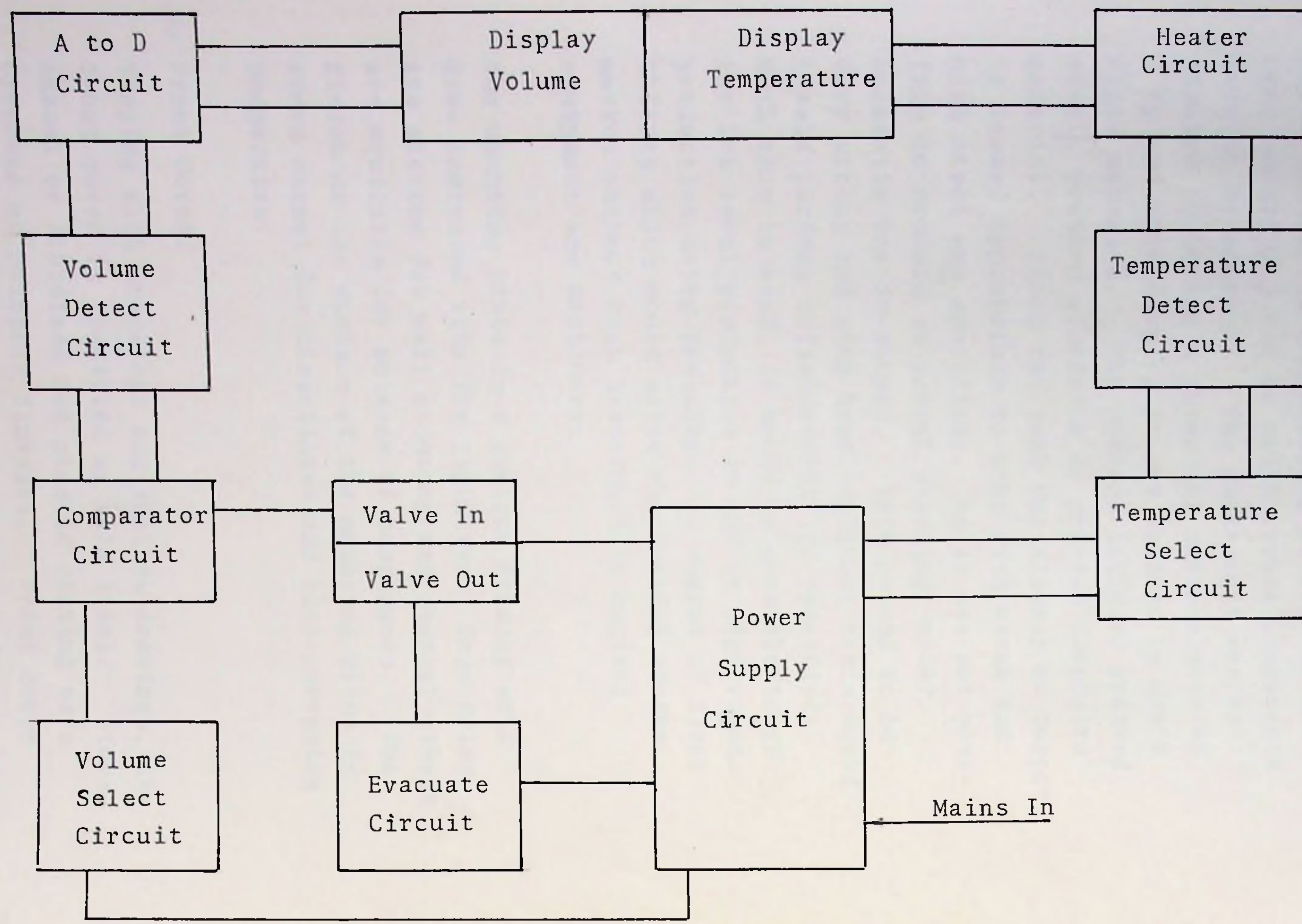


Fig. 8. Circuit Block Diagram.

3.4. Mounting Plate.

With the control system devised and dimensions approximated, it was possible to work on the rear mounting plate to which system components were to be mounted. The whole unit was estimated as having a potential maximum mass of 8 Kg and accordingly, it was decided to use a rigid material. The options included pressed steel, pressed aluminium or pressed composite material. Since the tank was already of copper it seemed appropriate to stay with metal and mild steel was specified. As it was not possible to produce an actual pressing, a GRP facsimile was developed. This proved to be very strong and with heat resistant resin would itself perform satisfactorily if specified. With this in mind, it would be possible to go for low level production in GRP or high volume production using pressings - a degree of flexibility which would allow the testing of the market without high investment in capital equipment and machinery.

The mounting plate is a shallow drawing with five impressed ribs for rigidity. Four holes are pierced for wall mounting and several others are available for bolt-on of components. The finish on the surface of the mounting plate is stove enamel for cleanliness and anti-corrosion properties.

3.5. Front Cover.

Staying with pressings and shallow drawings, the front cover is specified as mild steel. Stove enamel or fluidised bed plastic coating were proposed as possible finishes. Front cover temperatures were planned so as not to exceed 40°C. It seemed reasonable to consider even a vacuum forming but this was ruled out on the grounds that creep was a potential hazard. As with the mounting plate, GRP was used to simulate the drawing. The cover is essentially a rectangular box or shell and the problems in drawing it to a depth of 65mm are not major. As the ratio of depth to corner radius is approximately equal to 6 (i.e. 65mm:10mm) it would be possible to draw it in one go but two draws are likely to be more successful.

3.6. Interface

The design and layout of the switch panel presented several problems. The most significant of these lay in whether to offer a push button system or a twist knob system. The twist knob system scores over push buttons in that it reduces the actual number of switches required and consequently is cost effective. However, in terms of ease of operation and aesthetic appeal, push buttons undoubtedly offer a better solution. The quantity of buttons, twelve in all, seems a lot but the panel space is quite large and the graphic detailing has been carried out so as to minimise confusion. The display has been divided into 'cups' and 'litres' options so that the user can define his needs in terms of either. The push buttons are arranged so as to allow summing of quantities. Depressing a second button simply adds the quantity specified to the first amount - provided of course the maximum is not exceeded.

The switch panel itself is an injection moulding with receiving members to take switches and displays. The graphic detailing is screen printed onto the panel. Plastic and aluminium extrusions were also considered for the switch panel. Given a low volume output situation, these options would be more actively considered.

In deciding upon push button and display details several ergonomics sources were consulted. Stockbridge [24] was the most definite on the subject of choice of controls:

> "The question is 'which control and display system should one use?' Having read the paper one can answer:
>
> 1. The one which is both display and control, and is self illuminated.
> 2. The control you push instead of grasp.
> 3. The control which offers a large target area for the finger".

Points 2 and 3 have been directly acted upon. Point 1, however, is regarded as being applicable to more critical controls where fast reaction, time and minimum scope for error obtain. Push button size recommendations are tabulated by Stockbridge as defined by several authors and experimentalists. There appears to be a consensus that minimum push button diameter, no matter what the operation, should not be less than 12mm. A recommendation of 20 to 30mm distance between centres of buttons is given also depending on button configuration. Minimum recommended displacement distance is put at 2mm.

In keeping with the overall form of the unit, the following button dimensions were arrived at:

Square	12 mm
Distance between centres	17 mm
Displacement	1.5 mm

3.7. Exit Pipe Detailing.

One of the problems with the exit pipe is that water of boiling temperature must be capable of flowing through it. The hazard of touching a metal pipe at this temperature is obvious. It was decided to carry the water through a central core of copper in an accetal moulding which would form part of the front cover when not in use.

Parts List and Cost Estimates.

The following ex-works cost has been estimated for the water heating unit designed.

TABLE 12

PART NO.	DESCRIPTION	EX-WORKS COST ESTIMATE IR£
01	TANK	5.00
02	HEATING ELEMENT	2.50
03	SOLDER	0.25
04	SEALS	0.50
05	FLANGES	0.50
06	FLOAT UNIT	5.00
07	BRACKETS	0.30
08	BACK PRESSING	3.00
09	FRONT DRAWING	5.00
10	SWITCH HOUSING	2.00
11	VALVES	5.00
12	TAP MOULDING + PIPE	3.00
13	ELECTRONICS	10.00
14	INSULATION	1.00
15	FIXINGS & FASTENERS	1.00
16	TOTAL:	44.05

Above figures are arbitrary and assume volume production.

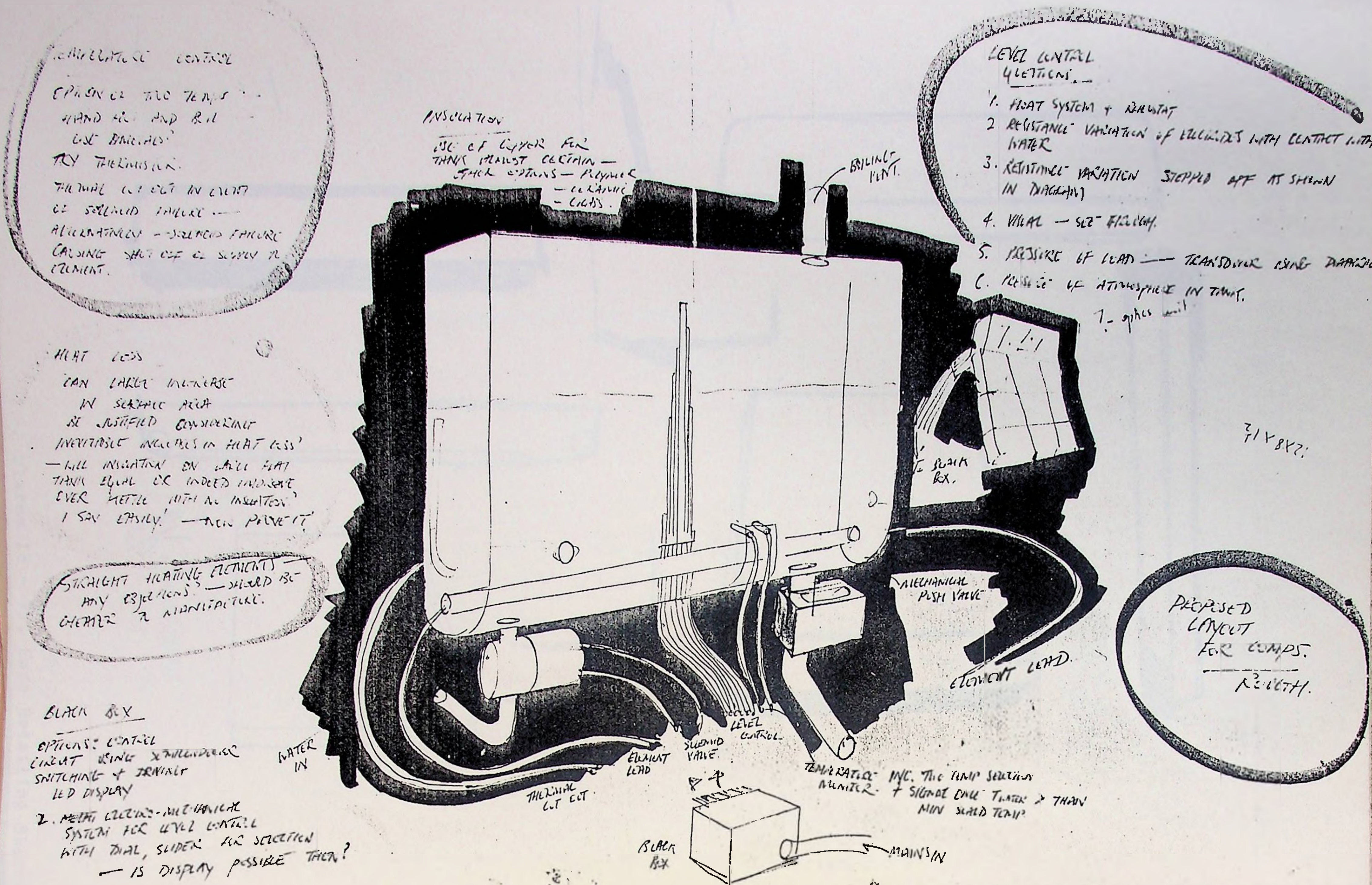
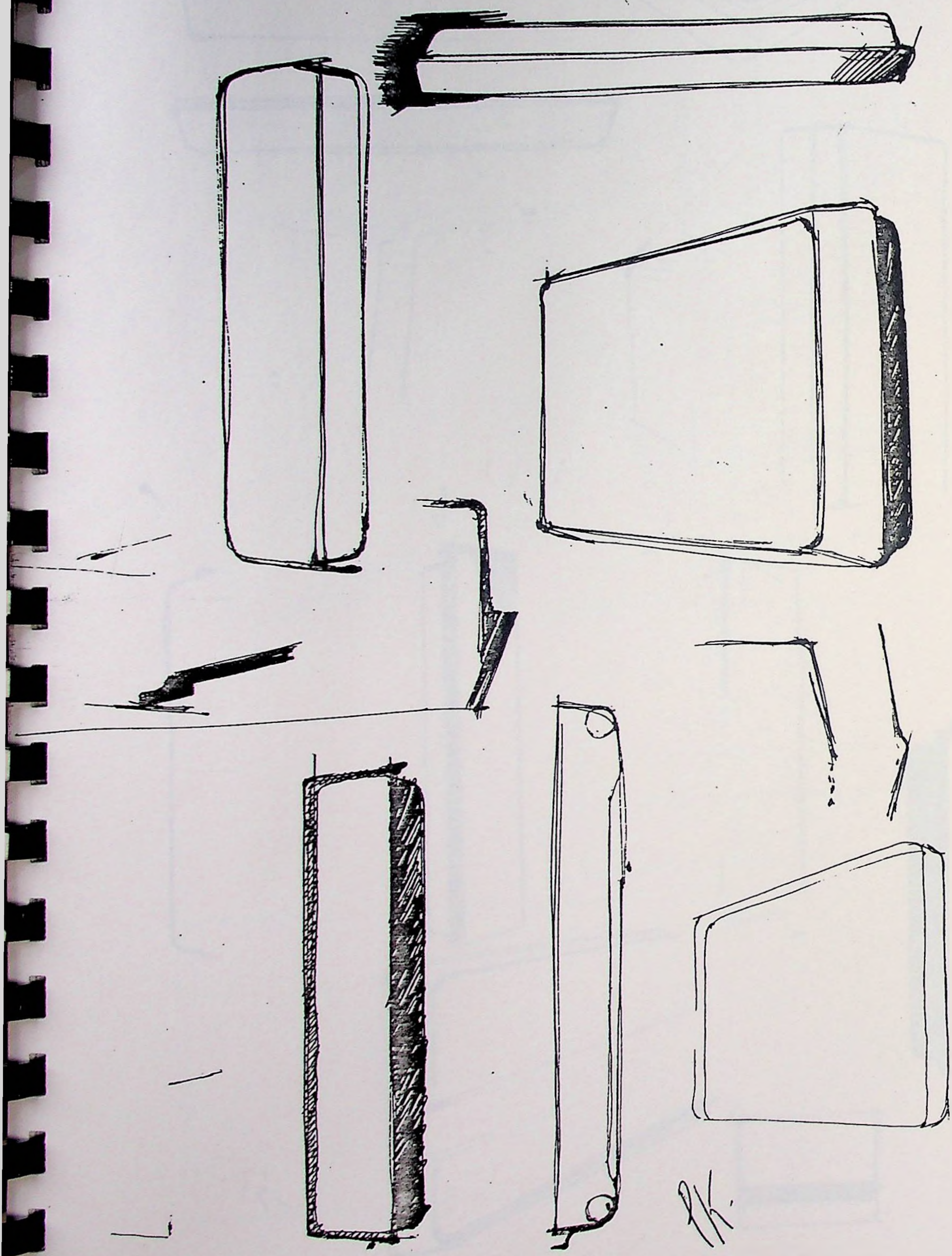


Plate 17. Early Technical Projection.



Plates 18 - 21. Case Detailing Sketches

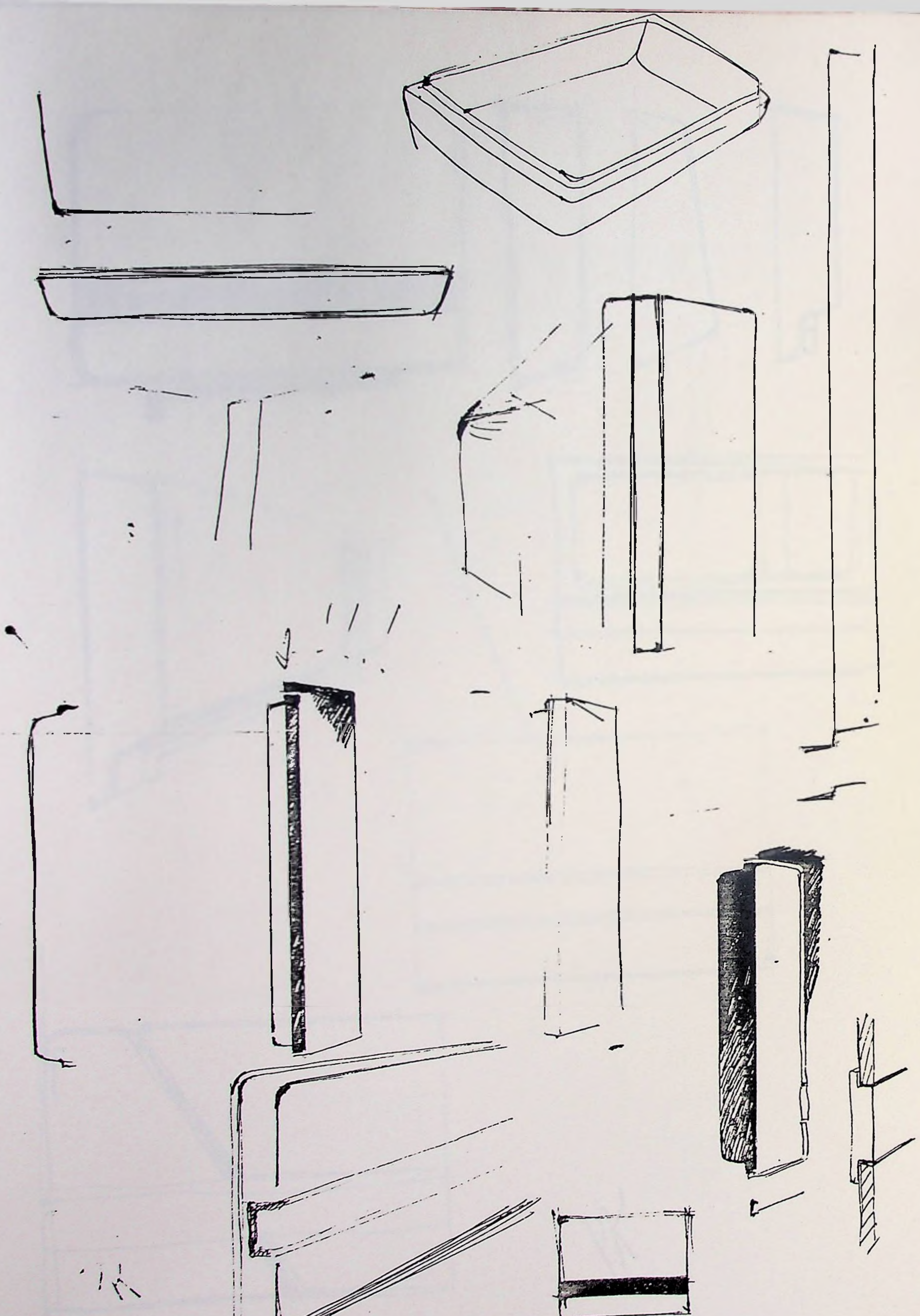


PLATE 19

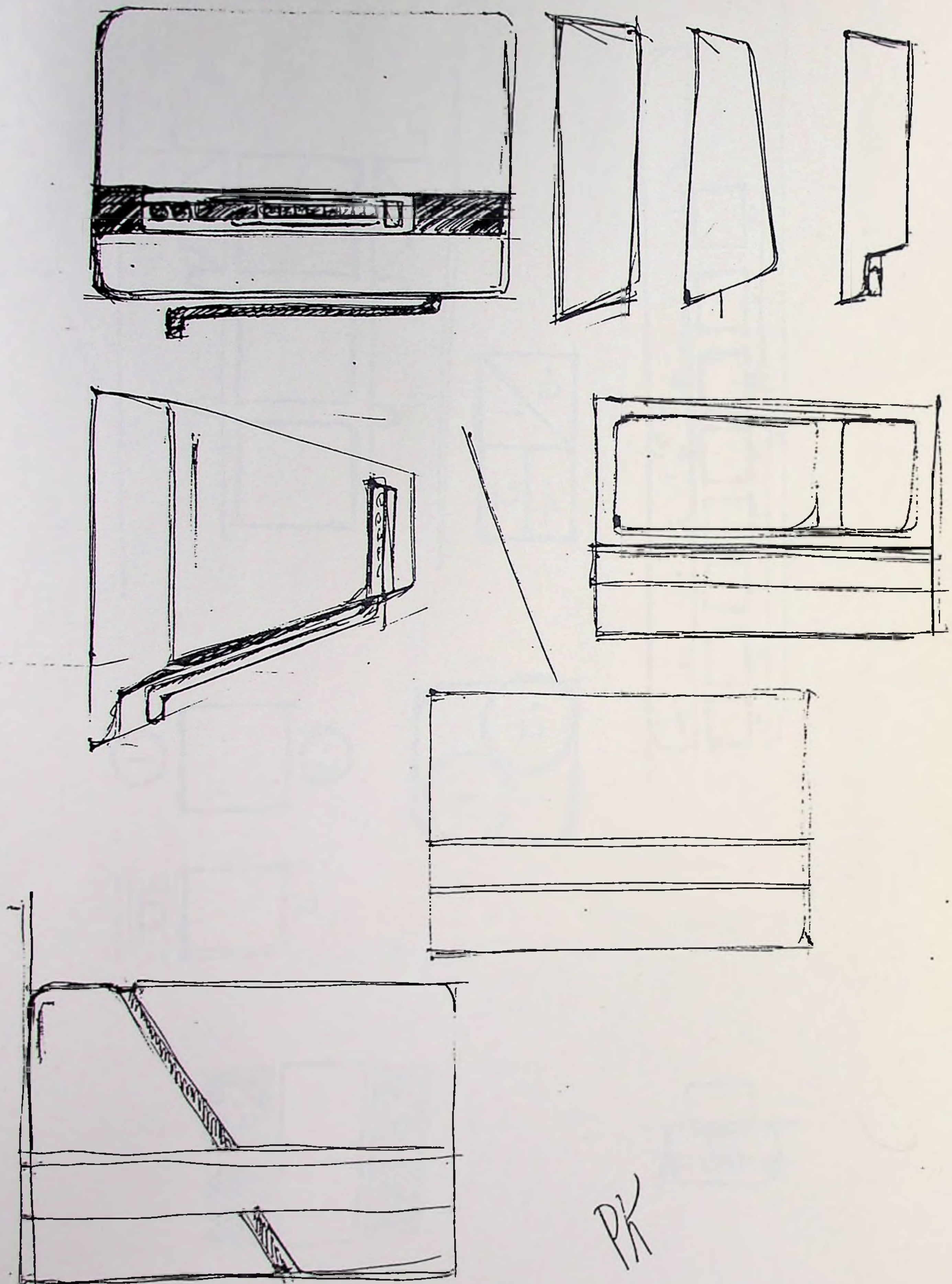


PLATE 20/21

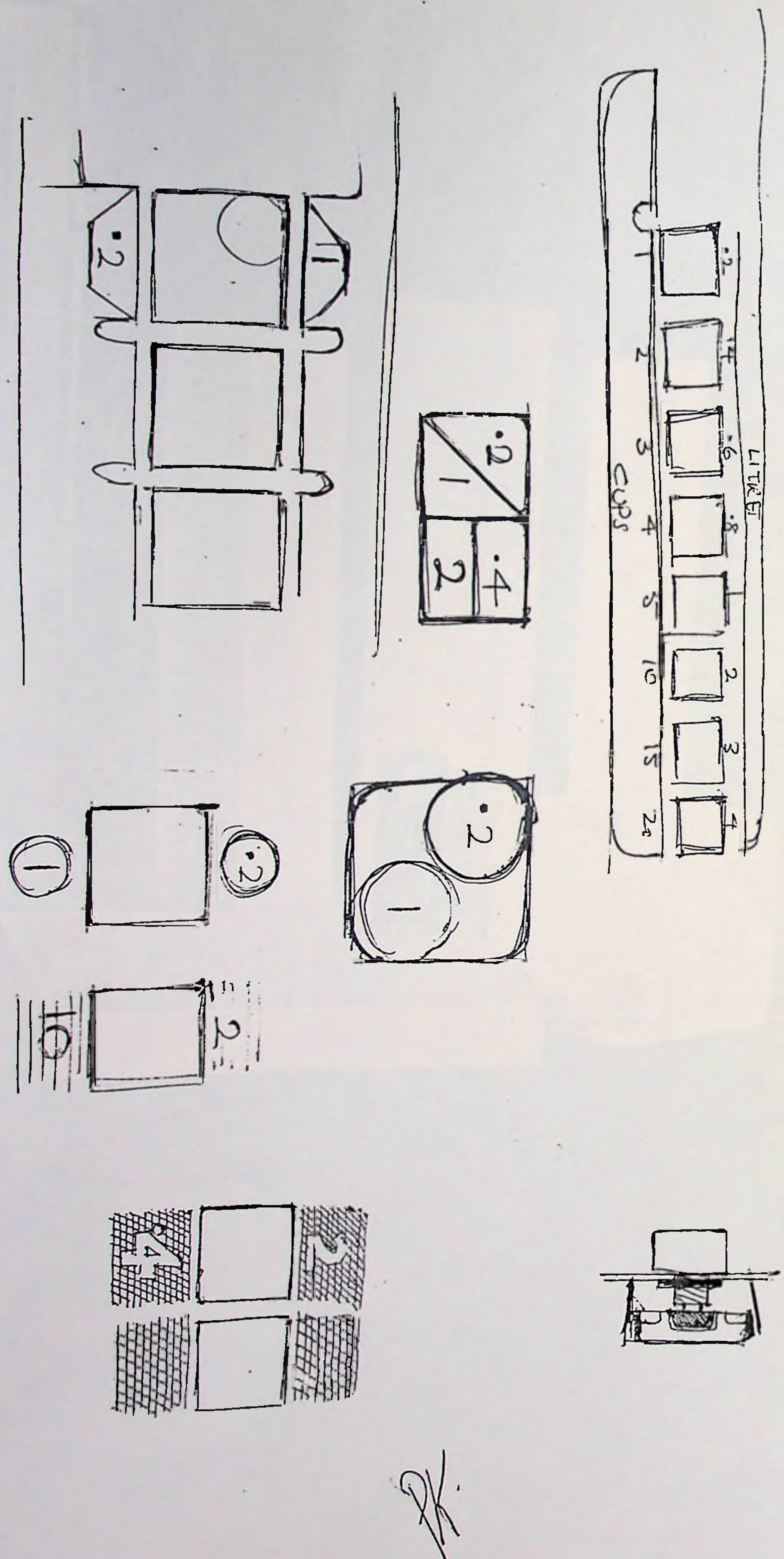


Plate 22. Button Detailing Sketches.

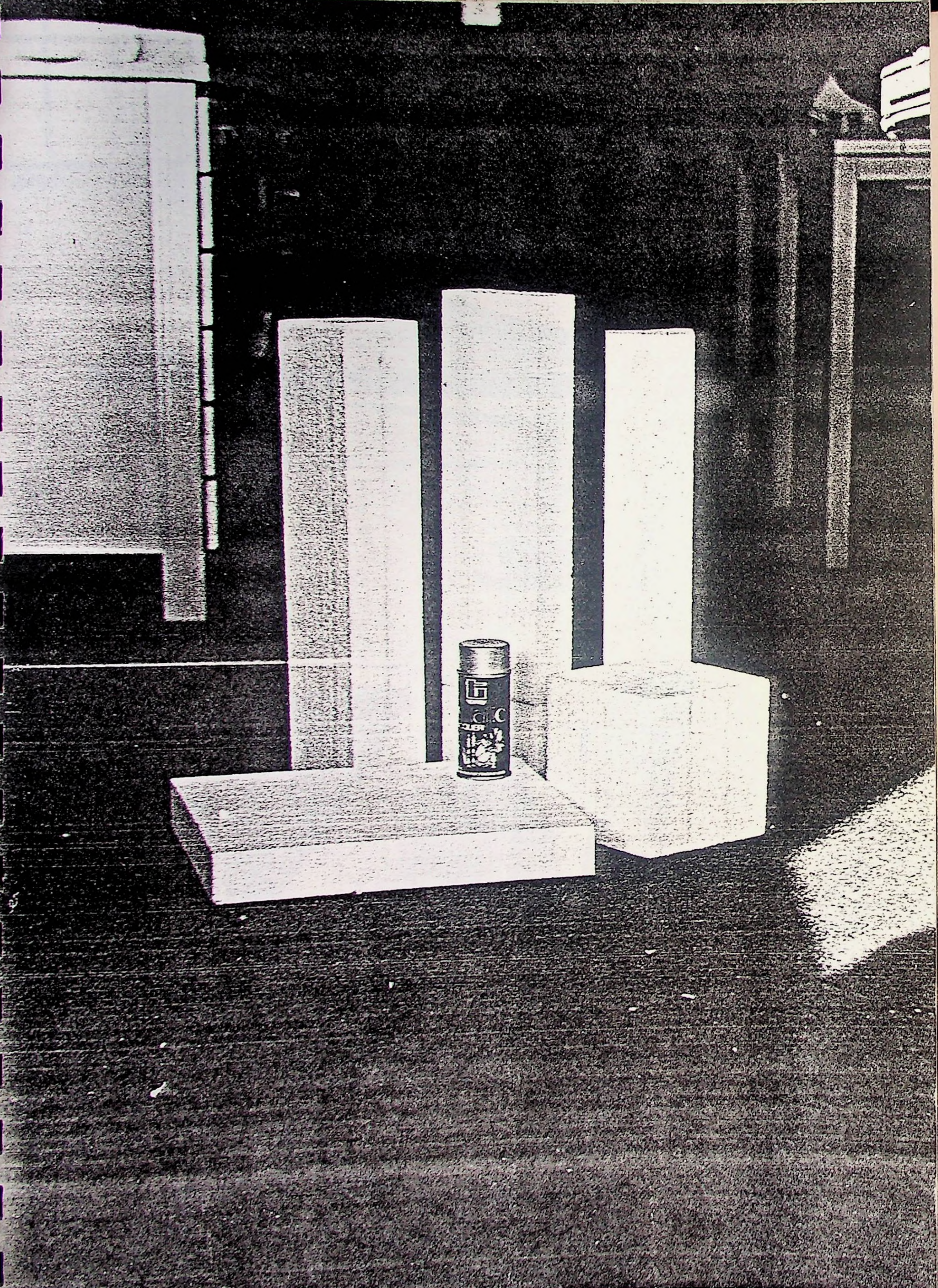


Plate 23. - Styrene Volume Forms

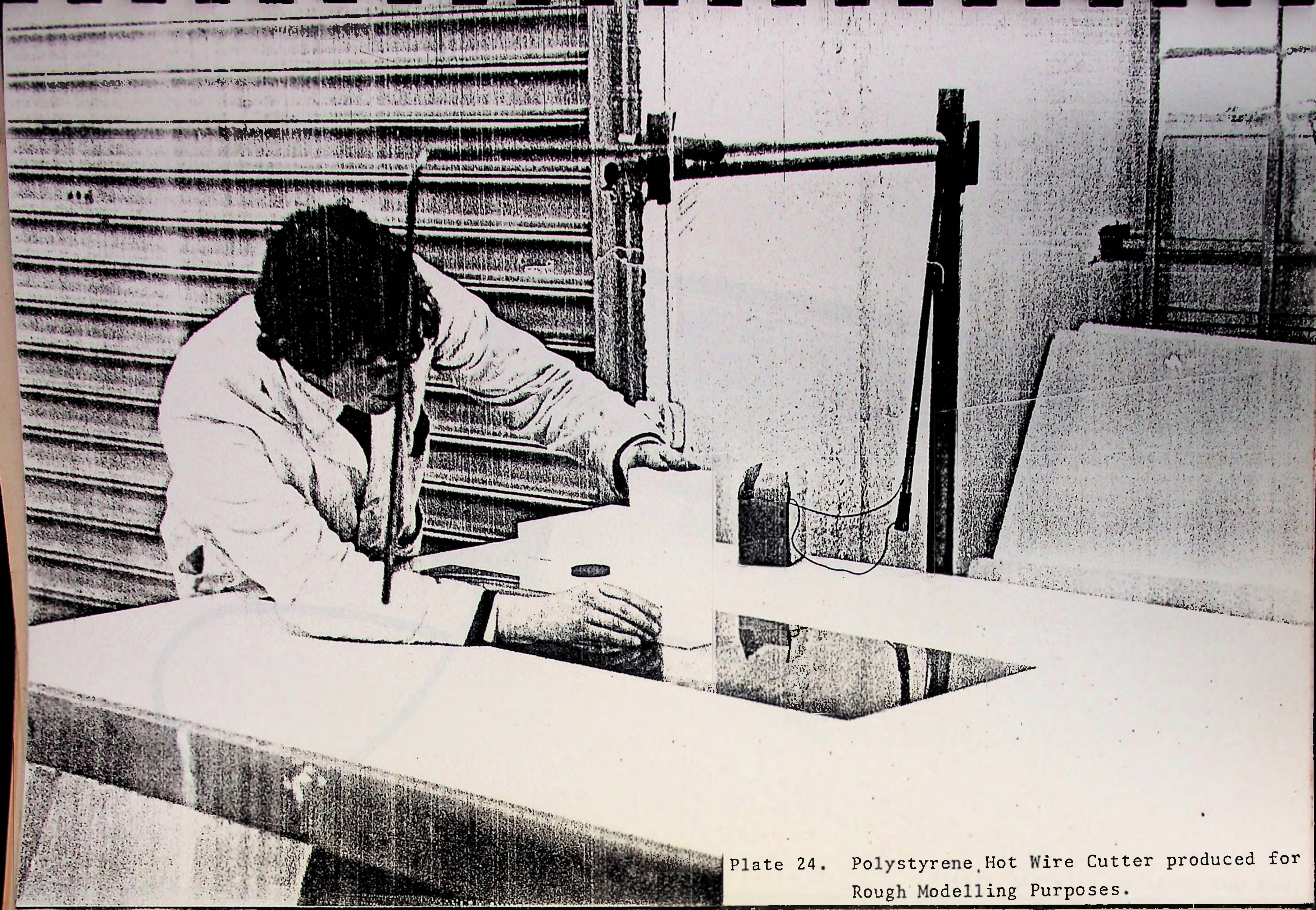


Plate 24. Polystyrene Hot Wire Cutter produced for Rough Modelling Purposes.

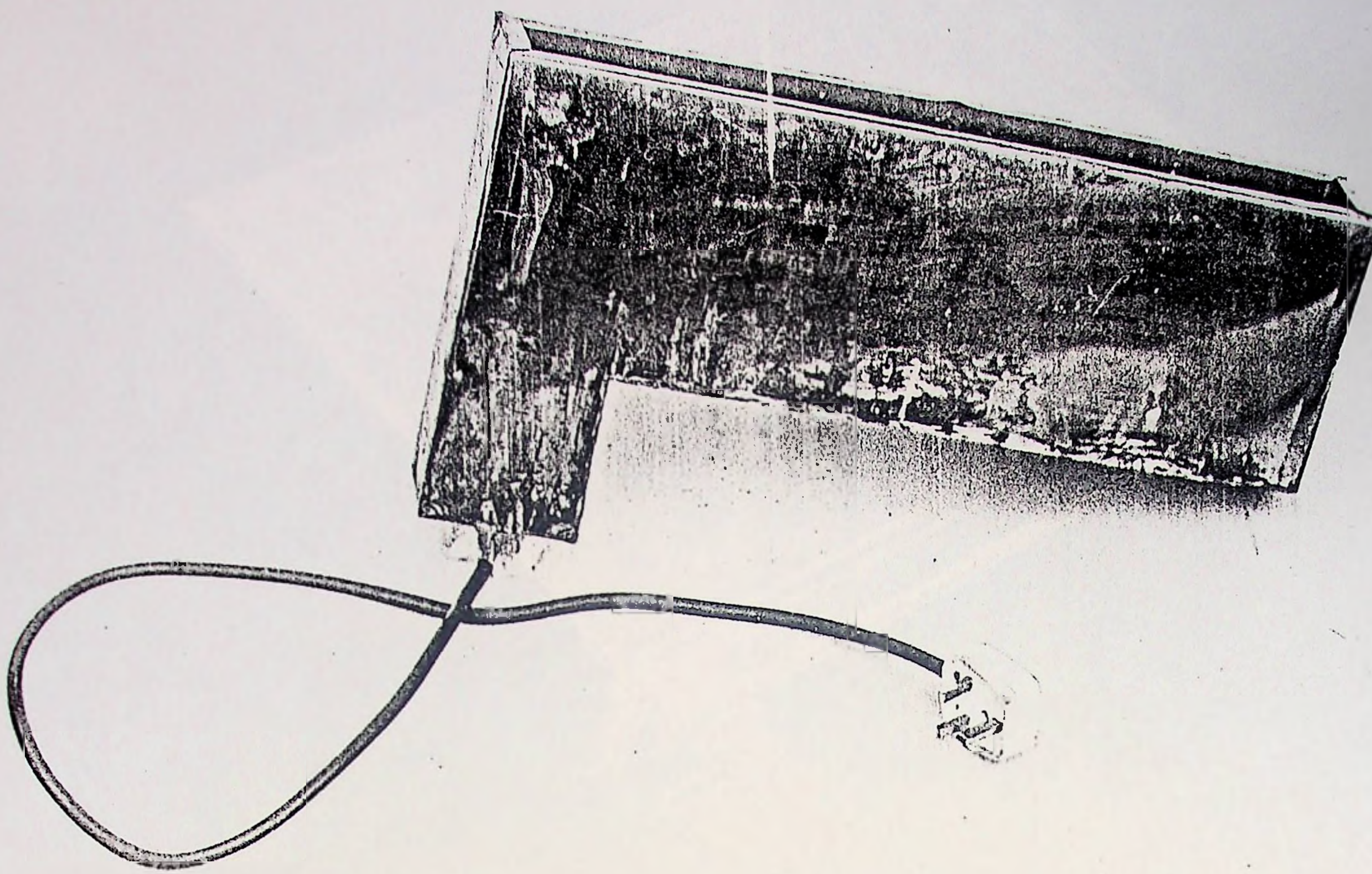


Plate 25. Early Water Tank with Recessed Cup End.

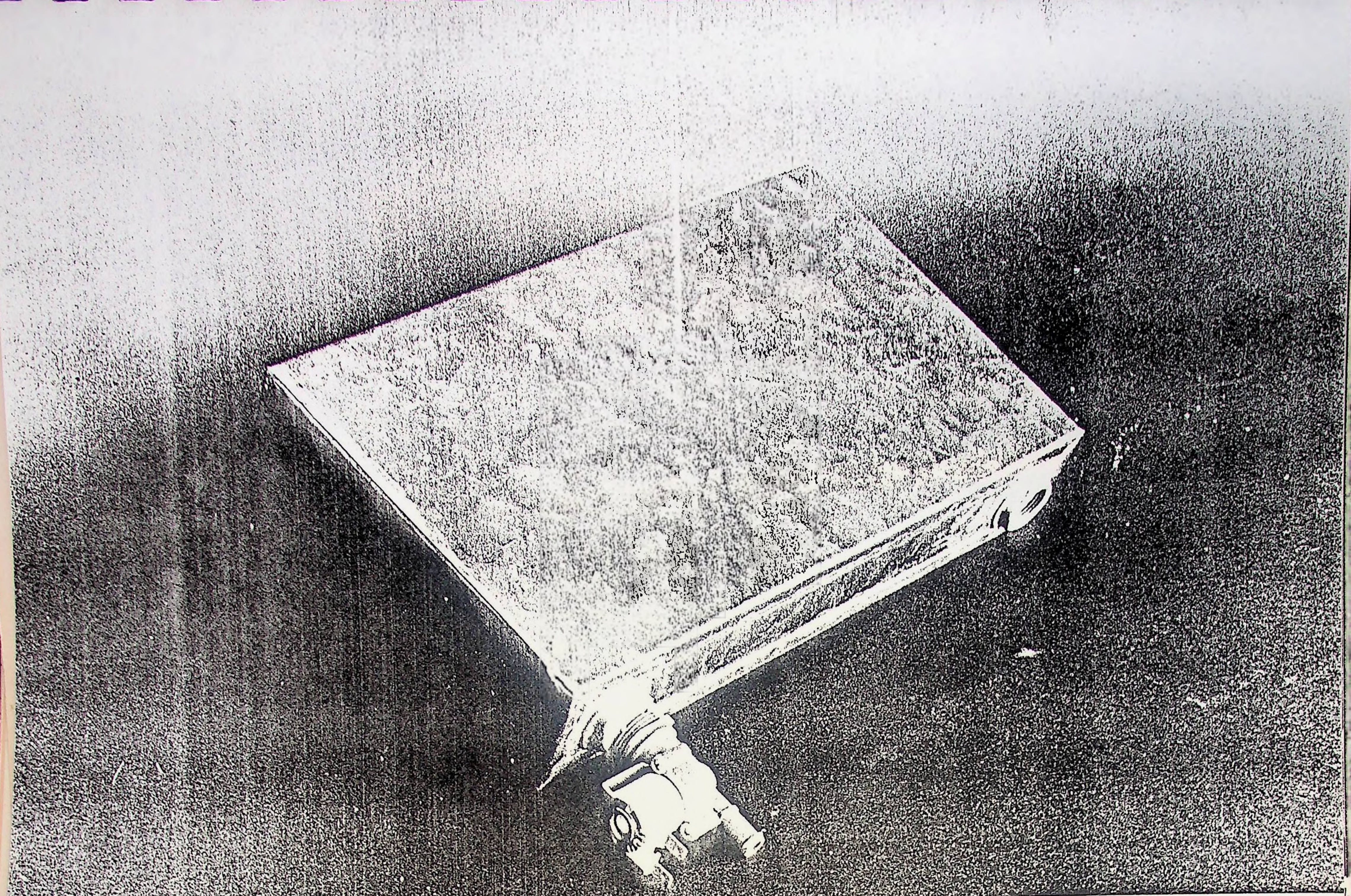


Plate 26. Later Water Tank.

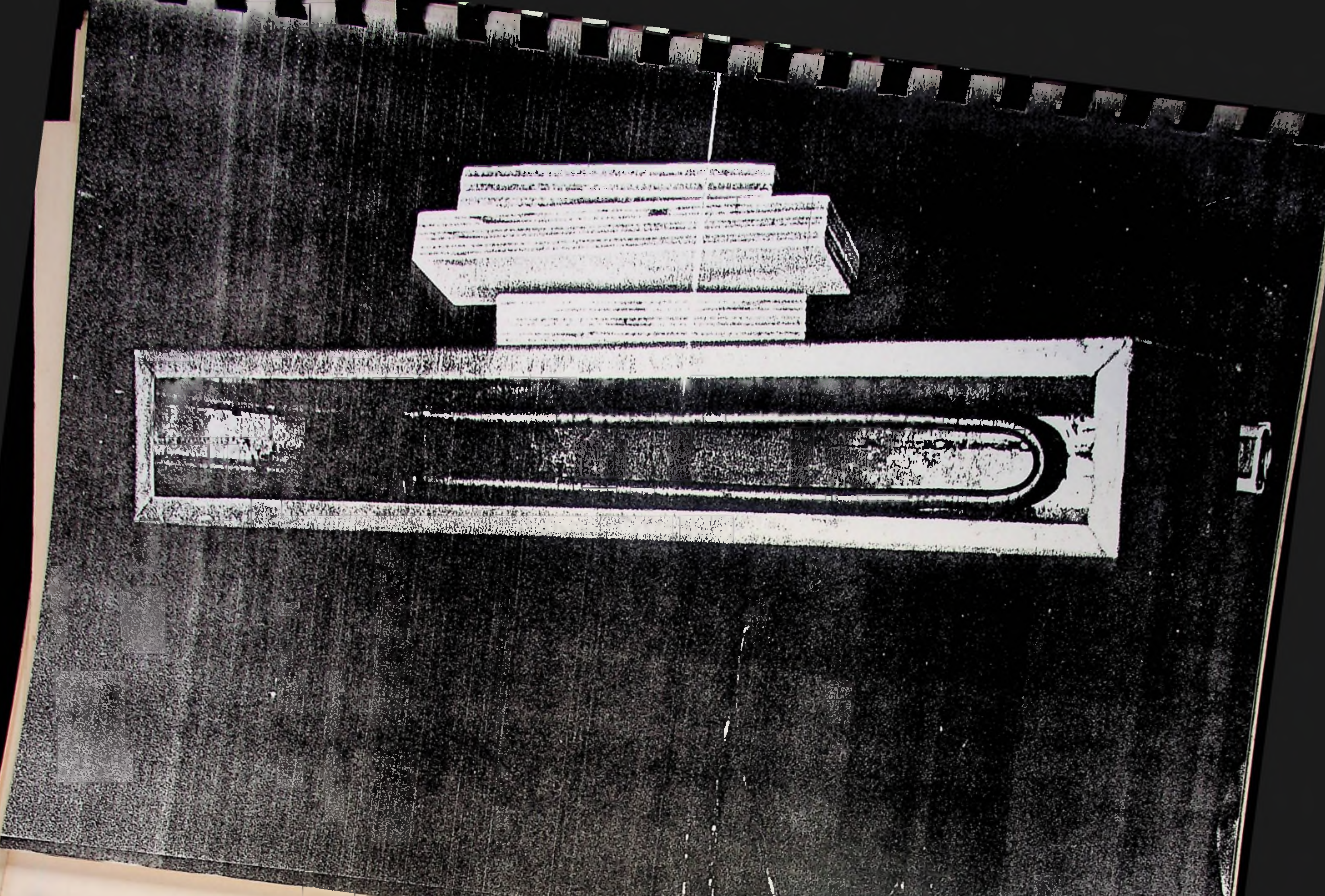


Plate 27. Later Water Tank, internal view.

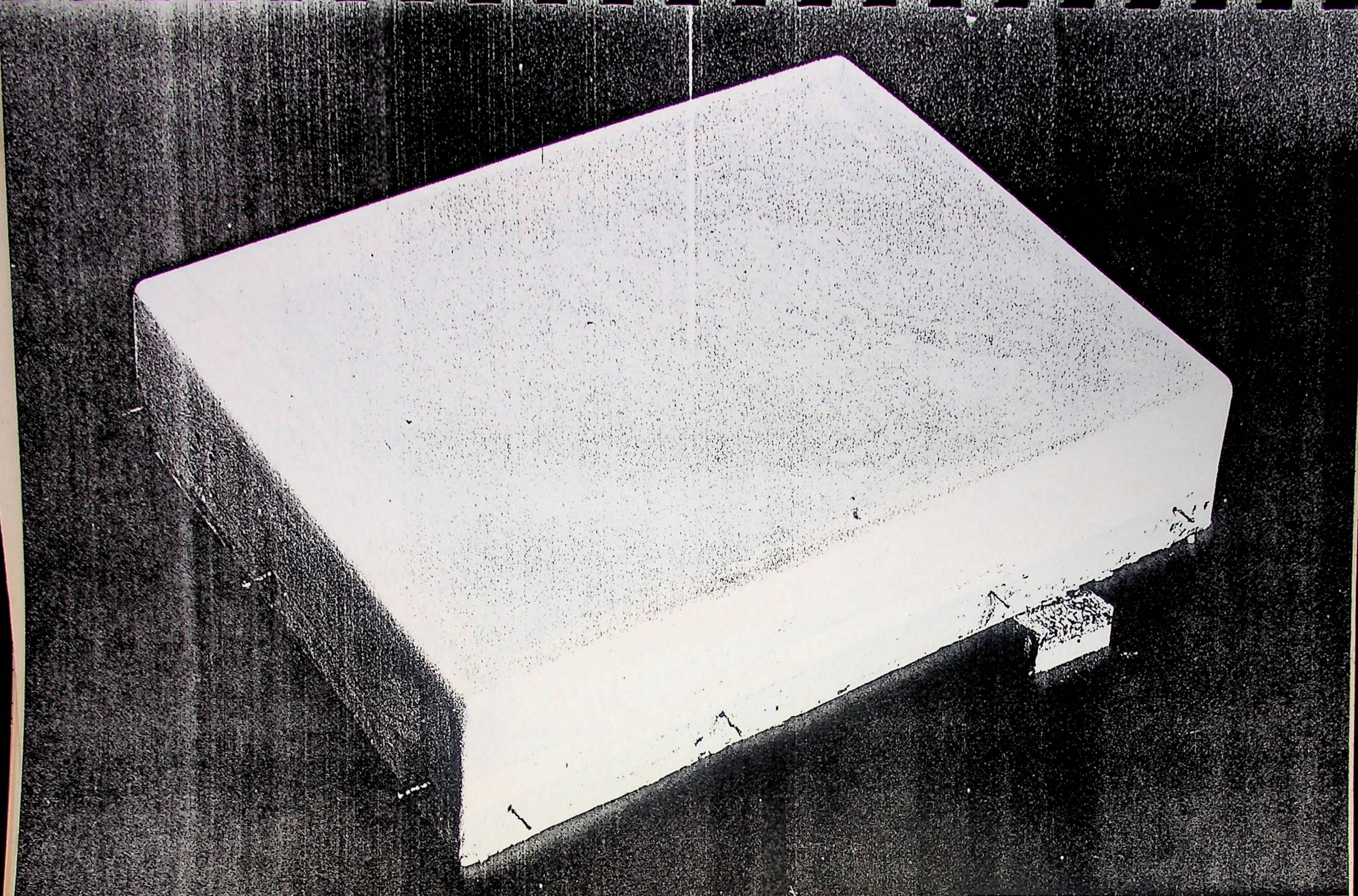


Plate 28. Hump Mould in Plaster.

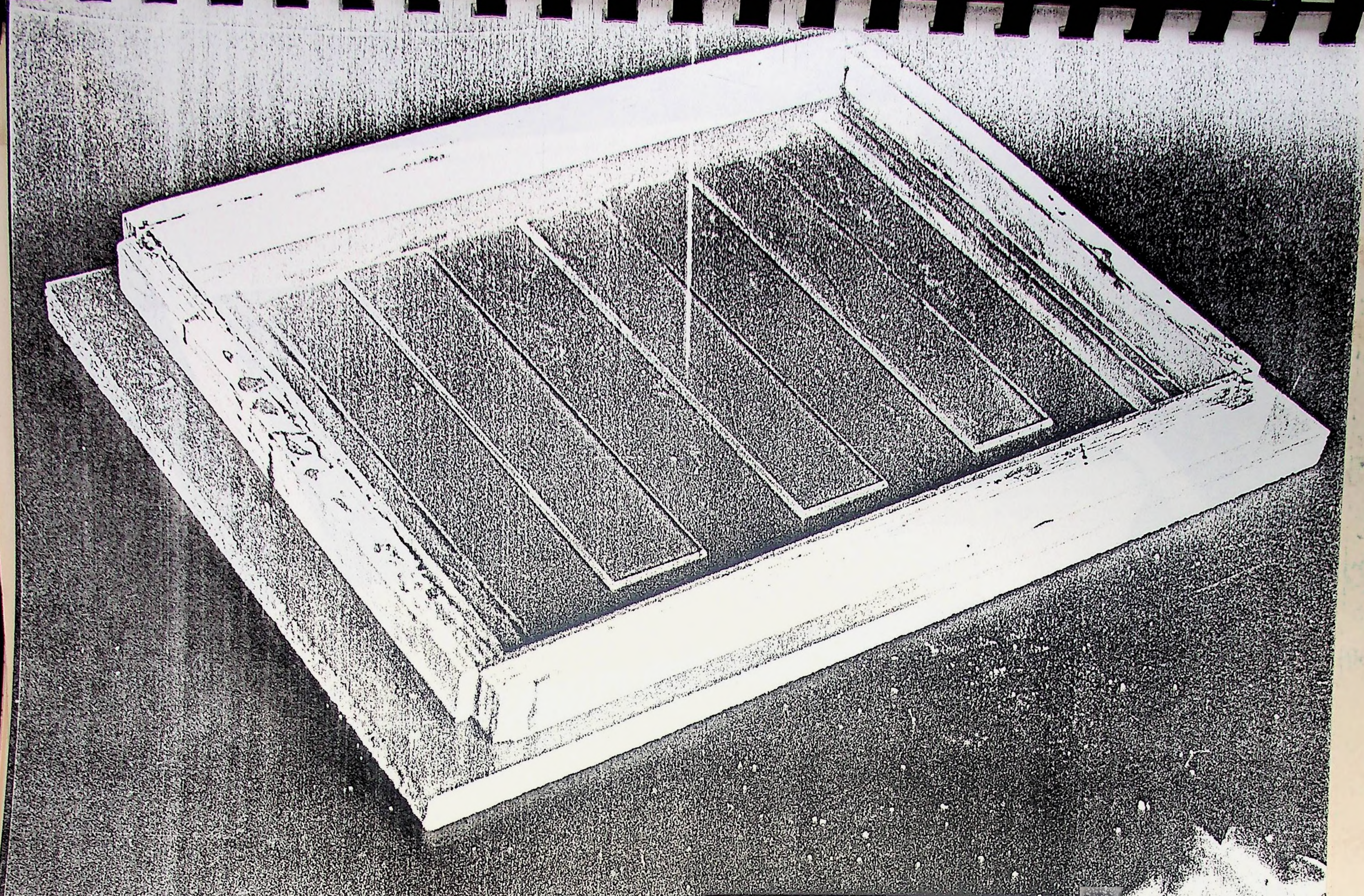


Plate 29. Perspex-lined mould for glassfibre lay-up

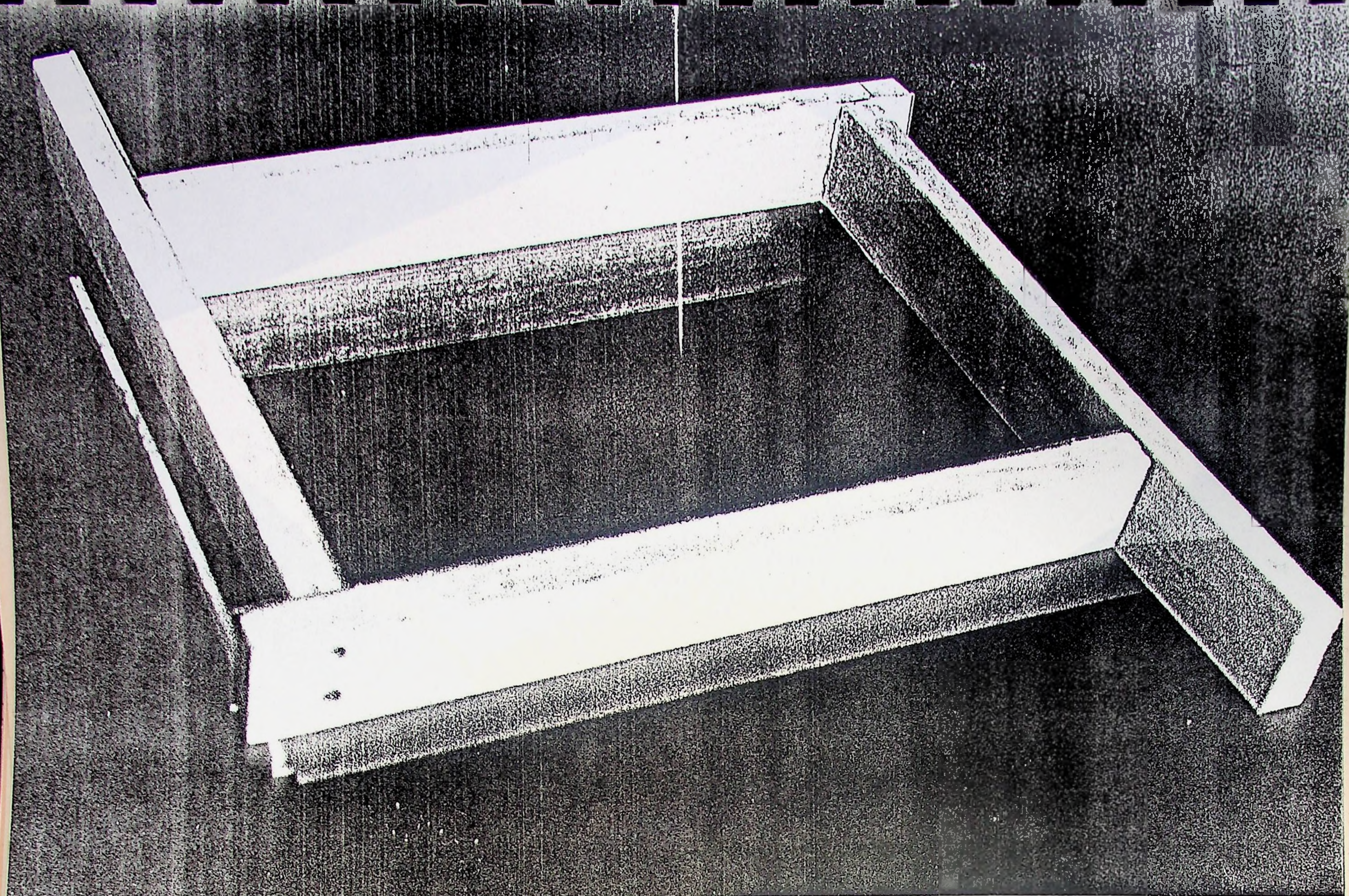


Plate 30. Front-Cover mould for glassfibre lay-up.

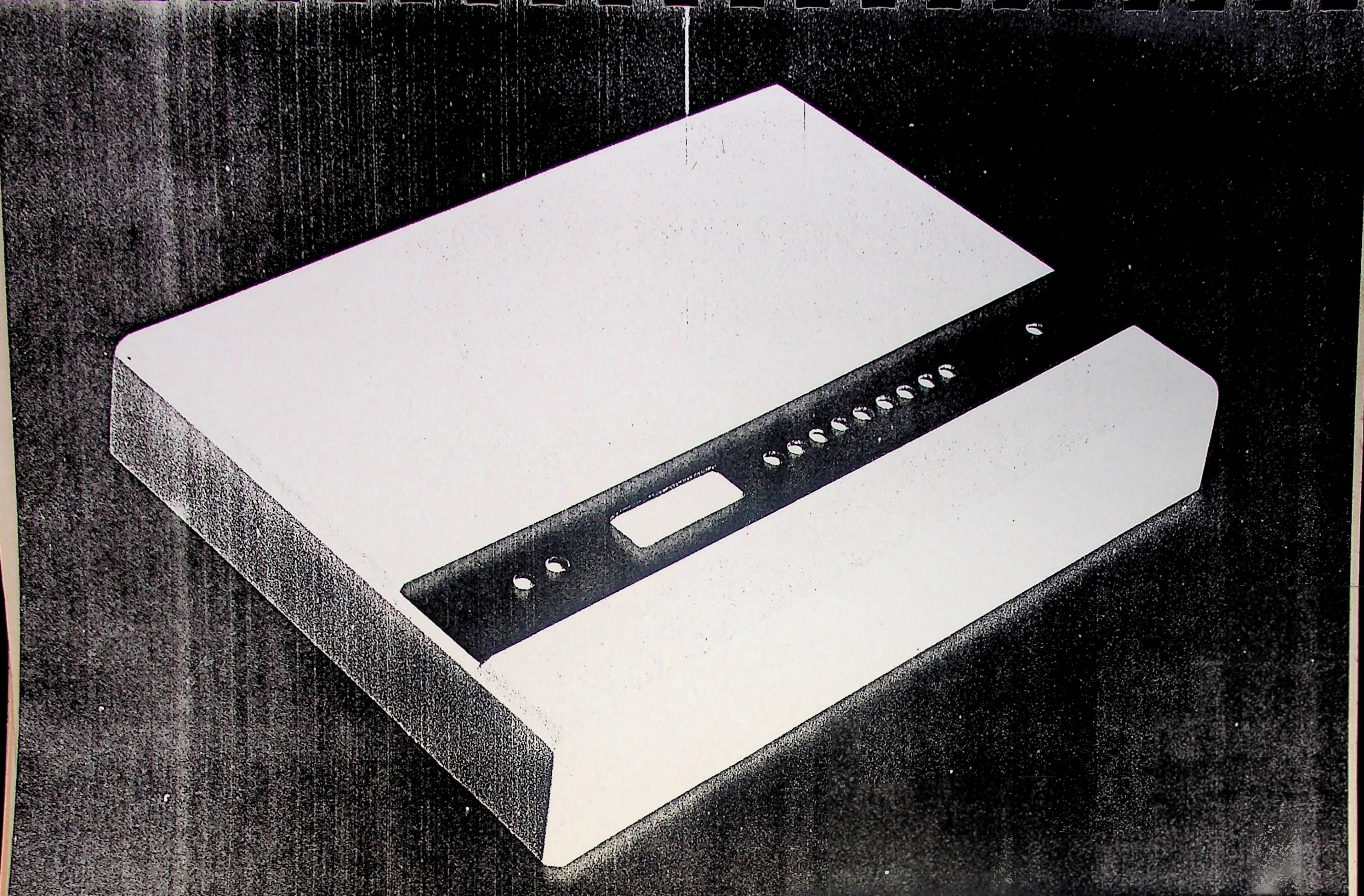


Plate 30 A Front cover with early swtich panel.

Plate 30.B Completed Unit.

Plate 31. Completed Unit Internal View.

SECTION 4. PRODUCT PHASE

4.1. Introduction.

Five intensive months have been spent carrying out the foregoing project. Much experience has been gained and a great deal learnt. If one was asked to state what was the most beneficial aspect of being involved in such a project, one would have to say that it is the opportunity that it gives for personal growth and development in terms of academic, social, technical and business education. Interaction with people in all walks of life is one of the most rewarding aspects of the experience. Another satisfactory feature of the project is the degree of independence it affords a student. This independence demands that the student develop a high degree of self-motivation and belief in the work which he or she is undertaking. The true challenge that this presents is most apparent in the later months of the project when coordination of all the earlier work is undertaken in the form of a design solution.

The solution arrived at in the present case opens the way for much discussion - discussion relating to the success or failure of the project as an experience, success or failure of the project in terms of the solution reached and future potential of the project, having gained this experience to date.

As the remainder of the text contains this discussion viewed from the author's personal standpoint it is written in the first person.

4.2. Design Project - Success or Failure?

On a personal level, in embarking upon this project, there were many things I had hoped to achieve. Among the most important of these was a desire to carry through the project with a sense of committment from beginning to end, meeting deadlines along the way. Largely I found I could manage this although many of my grander notions met an untimely end as the pressure of time distinguished the essential from the trivial.

Searching for help brought me into contact with people, many of them experts in their field. Through this experience, I gained an insight into how to approach people for help, where to go and who to go to. Generally speaking, people were very helpful, but not uncommonly, I came accross an unhealthy view as to what industrial design is all about. Explanation of my work helped me project a more balanced view of the Industrial Designer's Role and I feel that this has been a useful experience both in building up my own confidence and in propagating the industrial design "faith" - which I feel has an enormous contribution to make to Irish Industry.

So, in personal terms, the Design Project was a tremendous experience and a great success.

4.3. Design Solution - Success or Failure.

At present, there is a strong trend towards electronic energy monitoring systems being introduced into industry and latterly into the home. In the future, I can see that all energy consumed in the home will be monitored to the point where a programmable system will operate based on user energy usage patterns and budget. In particular, I envisage the hot water system being an integral part of this energy monitoring base and water will be heated automatically and economically at the push of a button anywhere in the home.

It was with these possibilities in mind that I conceived the present solution. The level and temperature controlled water heater/boiler is a potential part of the above system. In the ultimate system, the tank unit need not be seen at all, and the only visible clue that hot water is available may be an outlet tap and a number of keys on the household energy monitor keyboard dedicated to water heating.

I view the development of the water heater discussed in this report as a major step from the indiscriminate and uneconomic heating of water towards the fully monitored system referred to above. I chose to work on a discrete appliance rather than a household system as I feel that the latter has as much to do with the whole concept of living-space-design as with the production of domestic hot water. The small quantity unit has been designed with present day conditions in mind and I feel that with adaptation has real potential in the market place.

I deliberately set out to achieve a working appliance in order to approximate reality as well as possible. In industrial design terms therefore, I had to deal with very real problems that would face a practicing industrial designer. The visual solution adopted is characterised by the nature of the working appliance and in that sense, I hope it is an honest visual solution. In visual terms I am unhappy with several aspects of the product. One of the main features I had hoped to achieve was a feeling of flatness so that the unit stood only 60mm off the wall. Physical quantity requirements forced me to increase this to 90mm. However, the length and height dimensions also had to be altered considerably from those first proposed and to some extent the "flat" image has been recaptured.

I explored shape and colour possibilities using fibreglass models. I found that a fully radiused cover pleased me most visually, although I produced different finishes for comparison. Colour is traditional in the use of white and black but is also appropriate, particularly on the switchblock where strong colour has been used to provide an eyecatching display.

Within the scope of the brief, I feel that the solution is a valid one. With a lot of further development and simplification, I believe that it has future potential.

4.4. Future Potential.

The precise nature of this future potential is contained in a proposal for the development of a design based on the water heater produced for this project. I feel that a smaller unit, kettle size with just an exit port and a simpler lever control system would approach a saleable product more readily. I intend in the future, to draw on the fine learning experience I have had during the design of the present water heater and to develop this idea further.

4.5. Closing Words.

Once again, I would like to thank all who helped me make this project a valuable and fruitful learning experience.

SECTION 5. APPENDICES.

5.1. Footnotes.

1. See Section 5.5.
2. See Section 5.2.
3. See Section 5.2.
4. See Section 5.3.
5. See Section 5.3.
6. See Preface.
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5.2. List of Correspondents who replied with useful data.

ACUMEN MARKETING
217 - 218 Tottenham Court Road, London W1p 9AF.

AMDEA
593 Hitchin Road, Stopsley, Luton LU2 7UN.

APPLIANCE TESTING LABORATORIES
Cleeve Road, Leatherhead, Surrey KT22 7SB.

BRITISH STANDARDS INSTITUTION
2 Park Street, London W1A 2BS.

BUILD ELECTRIC BUREAU, THE
26 Store Street, London WC1 7BT.

BULPITT AND SONS LIMITED
P.O. Box 184, Albion Works, Albion Street,
Birmingham B1 3DL.

CALOR GAS IRELAND LIMITED
Long Mile Road, Dublin 12.

CHAFFOTEAUX LTD.
Concord House, Brighton Rd., Salfords, Redhill,
Surrey RH1 5DX.

CHOICE - AUSTRALIAN CONSUMERS ASSOCIATION
28 - 30 Queen Street, Chippendale NSW 2008
Australia.

CONSUMERS' ASSOCIATION
14 Buckingham Street, London WC2N 6DS.

CONSUMERS' RESEARCH INCORPORATED
WASHINGTON, N.J. 07882 U.S.A.

CONSUMERS' UNION
256 Washington Street, Mount Vernon, New York 10550.

ELECTRICITY COUNCIL, THE
Marketing Department, 30 Millbank, London SW1P4RD.

ERGONOMICS SOCIETY, THE
43 THE WESTERINGS, HOCKLEY, ESSEX.

GARDOM AND LOCK LIMITED
Alflow House, Soho Hill, Handsworth, Birmingham B19 1AP.

HADEN, D.H.
Mount Road, Burntwood, Wallsall WS7 OAW.

IMI SANTON LIMITED
Somerton Works, Newport, Gwent NPT OXU.

INSTITUTE FOR CONSUMER ERGONOMICS
University of Technology, Loughborough, Leicestershire.

INSTITUTE FUR HAVSWIRTSCHAFT IN DER BUNDESFORSCHUNGSANSTALT FUR ERNARUNG
7 Stuttgart - Hohenheim, Garbenstr. 13, W. Germany.

METWAY ELECTRICAL INDUSTRIES LTD.
Canning Street, Brighton BN2 2ES.

MINTEL PUBLICATIONS LTD.
20 BUCKINGHAM STREET, STRAND, WC 2N 6EE

NATIONAL HOUSEWARES MANUFACTURERS ASSOCIATION
1130 Merchandise Mart, Chicago IL 60654, U.S.A.

PURDUE UNIVERSITY LIBRARIES
West Lafayette, Indiana 47907 U.S.A.

REDRING ELECTRIC LTD.
Redring Works, Peterborough, England PE2 9JJ.

RETRA
Retra House, 57-61 Newington Causeway, London SE1 68E.

SASKATCHEWAN CONSUMER AFFAIRS
1871 Smith Streeg, Regina, Canada S4P 3V7.

SCIENCE MUSEUM,
South Kensington, London SW7 2DD.

SMITHSONIAN INSTITUTION
Washington D.C. 20560, U.S.A.

SAUNIER DUVAL LTD.
11 Decoy Road, Worthing, Sussex BN14 8ND.

T.I. CREDA LTD.
Creda Works, P.O. Box 5, Blythe Bridge, Stoke-on-Trent, ST119LJ.

TI GAS HEATING LTD.
Nottingham Road, Belper, Derby DE5 1JT.

THORN DOMESTIC APPLIANCES LTD.
New Lane, Havant, Hampshire, PO9 2NH.

TRADE, DEPARTMENT OF
Metrology, Quality Assurance, Safety and Standards
Division 4, Millbank Tower, Millbank, London SW1P 4QU.

UNDERWRITERS LABORATORIES INC.
Northbrook, Illinois, U.S.A.

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5.4. Engineering Drawings.

5.5. Additional Material.

CASE HISTORY LISTING


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DATE        DAY          TIME       AMBUL.     INFORM.    BUILDING          LOCATION             ACTIVITY            ACCIDENT TYPE          FIRST ARTICLE
      FIRST FUEL SOURCE      FIRST FEATURE    SECOND ARTICLE         SECOND FUEL SOURCE    SECOND FEATURE     FURTHER INTERVIEW          EMPLOYMENT
       AGE        SEX          FIRST INJURY          FIRST INJ. PART        SECOND INJURY        SECOND INJ. PART    INPATIENT DAYS          DISPOSAL
      SECONDARY DISPOSAL
------------------------------------------------------------------------------------------------------------------------------------------------------

23/ 3/79   FRIDAY      1800 HRS  NO AMBUL.  INFORM      FLAT        KITCHEN              FOOD PREP- WITH HEAT BURNING-CONT HEAT     KETTLES
      MAINS ELECTRICITY      .......           .......               .......              .......            UNKNOWN                 NOT EMPLOYED
       85 YRS    FEMALE     SCALDS             ANKLE                 SCALDS                 FOOT                           0 DAY(S)  OUT-PAT./ GP
      .......
*****  MAKING TEA-UPSET KETTLE BOILING WATER OVER SELF-PT HA  POOR SIGHT DUE CATARACTS

25/ 3/79   SUNDAY      2000 HRS  NO AMBUL.  NOT INF.   HOUSE       KITCHEN              EATING & DRINKING    BURNING-CONT HEAT     KETTLES
      MAINS ELECTRICITY      .......       HOT WATER-FM KETTLE   NEVER POWERED         HOT                UNKNOWN                    .......
       9 YRS     MALE       SCALDS              KNEE                 .......                  .......                      0 DAY(S)  OUT-PAT./ GP
      .......
*****  SCALDED LEG WHEN POURING WATER FROM KETTLE TO CUP

27/ 3/79   TUESDAY     2000 HRS  AMBUL      NOT INF.   FLAT        KITCHEN              FOOD PREP- WITH HEAT BURNING-CONT HEAT     HOT WATER-FM KETTLE
      NEVER POWERED          .......       KETTLES               MAINS ELECTRICITY     .......            FURTHER INTERVIEW          .......
       ? YRS     MALE       SCALDS              LEG - UPPER PART     .......                  .......                      0 DAY(S)  HOME
      .......
*****  MAKING TEA BOILING WATER FROM KETTLE SPLASHED OVER HIM

28/ 3/79   WEDNESDAY   1800 HRS  NO AMBUL.  NOT INF.   HOUSE       LIVING/DINING AREA   CHILDREN PLAYING     FALL ON SAME LEVEL    KETTLES
      NEVER POWERED          STILL HOT     FLOOR UNSPEC COVERING NEVER POWERED         .......            NO INTERVIEW               .......
       4 YRS     FEMALE     BURNS               TRUNK - LOWER PART   .......                  .......                      0 DAY(S)  OUT-PAT./ GP
      .......
*****  CHILD FELL DOWN ONTO HOT KETTLE WHICH WAS ON FLOOR-PLAYING AT THE TIME

28/ 3/79   WEDNESDAY   0800 HRS  NO AMBUL.  INFORM     HOUSE       KITCHEN              FOOD PREP- WITH HEAT EXPLOSION ACCIDENT    STEAM (FROM KETTLE)
      NEVER POWERED          .......       KETTLES               MAINS ELECTRICITY     .......            FURTHER INTERVIEW          FULL-TIME EMPLOYED
       39 YRS    MALE       SCALDS              WRIST                SCALDS               FINGER/ THUMB                   0 DAY(S)  HOME
      .......
*****  PUT KETTLE ON-DIDNT REALISE NO WATER IN IT-PUT COLD WATER IN-SCALD ARM WITH STM

28/ 3/79   TUESDAY     1200 HRS  NO AMBUL.  INFORM     HOUSE       KITCHEN              FOOD PREP- WITH HEAT BURNING-CONT HEAT     KETTLES
      MAINS ELECTRICITY      .......       HOT WATER-FM KETTLE   NEVER POWERED         .......            FURTHER INTERVIEW          NOT EMPLOYED
       54 YRS    FEMALE     SCALDS              WRIST                .......                  .......                      0 DAY(S)  OUT-PAT./ GP
      .......
*****  WHILE MAKING CUP OF TEA ELECTRIC KETTLE SLIPPED-WATER POURED OUT SCALDED HAND

30/ 3/79   FRIDAY      1400 HRS  NO AMBUL.  NOT INF.   HOUSE       LIVING/DINING AREA   CHILDREN PLAYING     BURNING-CONT HEAT     HOT WATER-FM KETTLE
      NEVER POWERED          HOT           KETTLES               NEVER POWERED         .......            NO INTERVIEW               .......
       7 MTHS    MALE       SCALDS              TRUNK - UPPER PART   SCALDS               ARM - AREA UNSPEC               0 DAY(S)  OUT-PAT./ GP
      .......
*****  PULLED KETTLE OF HOT WATER OVER HIM-KETTLE ON FLOOR-MOTHER BATHING OTHER CHILD
```

Degree Project 1981
SCHEDULE & PROGRESS

Date	18.2.81
Sheet No.	71

1. DIPPER
2. DRAWING — DATA PRES.
3. TRANSFORMER - RADIONICS
4. ISEULT 4.15. PM
5. THESIS — COMPLETE CHAP. 1
6. CONTINUE BOOK OF LINE & FORM.

1. ✓
2. STARTED TO DRAW OUT A2 ROUGH PRESENTATION SHEETS RELATED TO ENERGY, EFFICIENCY ETC.
3. GOT PART NO. ETC. FOR TRANSFORMER FROM RADIONICS.
4. SAW ISEULT. REVIEWED PROGRESS OVER PREVIOUS TWO WEEKS AND CONCLUDED THAT PICTURE WAS NOT QUITE AS BLEAK AS THOUGHT: ACHIEVEMENTS FOR THE PERIOD INCLUDED: COMPLETION OF H/WIRE M/C.
   COMPLETION OF THESIS CHA 1.
   START OF DRG.
   RECEIPT OF PHOTOS FROM SCIENCE MUSEUM.
5. THESIS CHAP 1. COMPLETED — TO BE TRANSCRIBED FOR INSPECTION
6. DRG. NOT DONE DUE TO ATTENDANCE AT SDI LECTURE ON SVENSK FORM — VERY INTERESTING.

NATIONAL COLLEGE OF ART AND DESIGN KILDARE ST. DUBLIN 2

Dear Sir,

My major thesis/design project submission for the Bachelor of Science Degree in Industrial Design Engineering will be based on a study of the use of small quantities of hot or boiling water in domestic environments. Currently I am collecting data and I write to you for help.

This thesis/design project will take the form of a historical treatise of early water heating appliances through to the development of a new design and the construction of a prototype. I am principally interested in learning about electric kettle design, and small tank or instantaneous water heaters, gas, electric or other information which will help me trace the development of any of these products as they have evolved over the years will be invaluable to me.

I am also interested in collecting data relating to small water heating/boiling products currently being manufactured by yourselves - technical specifications,. design features, promotional literature.

Any contribution that you may be able to make will be greatly appreciated and I should like to thank you in advance for any trouble you may go to on my behalf.

Yours sincerely,

Philip J. Kenny
Fourth Year Industrial Design Student
Faculty of Design

PLEASE REPLY TO: Department of Industrial Design
Princes Street
Off Townsend Street
DUBLIN 2

Telephone 682911

NATIONAL COLLEGE OF ART AND DESIGN KILDARE ST. DUBLIN 2

PLEASE REPLY TO: Department of Industrial Design, Princes Street,
Off Townsend Street, DUBLIN 2

Dear Sir,

My major thesis/design project submission for the Bachelor of Science Degree in Industrial Design Engineering will be based on a study of the use of small quantities of hot or boiling water in domestic environments. Currently I am collecting data and I write to you for help.

The following headings define particular areas relevant to my work. Perhaps you may be able to contribute information which relates to one or more of these headings.

1. Consumer behaviour - the use of small quantities of hot or boiling water in domestic environments, when used, where used, how used, sales statistics.

2. Safety and hot water appliances - accident descriptions and statistics related to the use of water heaters such as kettles, small tank heaters, geysers etc.

3. Appliances - existing appliances designed to heat small quantities of water, their features styling, efficiency, consumer attitudes to these appliances.

4. Historical - details, descriptions of small water heating appliances of the past, their design evolution, manufacturers etc.

This thesis/design project will take the form of a historical treatise of early water heating appliances through to the development of a new design and the construction of a prototype. I am principally interested in learning about kettle design and small tank or instantaneous water heaters.

Any information will be greatly appreciated: photocopies of articles or studies, references or guidance as to where information may be found will be most welcome.

I should like to thank you in advance for any trouble you may go to on my behalf.

Yours sincerely,

Philip Kenny
Fourth Year Industrial Design Student
Faculty of Design

Telephone 682911