MINISTRY OF FUEL AND POWER

AND THE

DEPARTMENT OF
SCIENTIFIC AND INDUSTRIAL RESEARCH

DOMESTIC HEATING IN AMERICA

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DOMESTIC HEATING IN AMERICA

A STUDY OF HEATING, COOKING AND HOT WATER SUPPLY IN SMALL HOUSES IN U.S.A. AND CANADA

Report of a Joint Party from the Ministry of Fuel and Power and the Department of Scientific and Industrial Research

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Foreword

It is generally recognised that British practice in the heating of dwellings leaves much to be desired. The subject is now being more intensively studied here than ever before and authoritative reports on the scientific and policy aspects have been published in recent months.*

When the Fuel and Power Advisory Council, appointed by the Minister of Fuel and Power to the late Government, was preparing its report on domestic fuel policy, the Chairman, Sir Ernest Simon, considered that the Council should be provided with first-hand knowledge of the latest developments in the U.S.A. and Canada. The same need had been felt in the Department of Scientific and Industrial Research. Accordingly, arrangements were made for a Joint Party, consisting of one Officer of the Ministry of Fuel and Power and two Officers of the Department of Scientific and Industrial Research (one from the Building Research Station and one from the Fuel Research Station) to visit the U.S.A. and Canada in the winter of 1944–45.

In the course of a three months' tour, the party discussed the subject with many architects and heating engineers, official and non-official, with manufacturers of appliances, housewives and research workers. They thus collected much information which they have put on record in the report now published, and which the Fuel and Power Advisory Council had before them when considering their recent recommendations.

It will be appreciated that methods and practice in the U.S.A. and Canada are not necessarily wholly applicable in this country. It should also be made clear that the publication of the report does not imply that the two Departments concerned are necessarily committed to the views expressed and the recommendations made. But the report is worthy of attention by all who are interested, from whatever aspect, in this subject.

The authors make very clear how much the success of their visit was due to the cordial welcome and ready help they received wherever they went. This opportunity is taken to underline, on behalf of the two Departments, the expression of appreciation recorded by their Officers in their report for the assistance so willingly given.

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* Report on Heating and Ventilation of Dwellings (Post-war Building Studies No. 19) by the Heating and Ventilation (Reconstruction) Committee of the Building Research Board of the Department of Scientific and Industrial Research, H.M. Stationery Office, 1945, price 2*s.* 6*d.*

Report on Domestic Fuel Policy by the Fuel and Power Advisory Council, Cmd. 6762, 1946, price 1/–.

Table of Contents

Appendices

List of Figures

List of Tables

Introduction

The proposal to send a mission to America came, in the first place, from the Fuel and Power Advisory Council. The object of the Mission was to study heating, cooking and hot water installations in small houses with a view to making recommendations on these matters which might be likely to benefit British housing. It was suggested that attention should be confined mainly to individual house heating or, at most, to the heating of small groups of houses. Consequently very little time was given to systems of District Heating or to the heating of large blocks of flats except in so far as they affected arrangements within the dwellings. [0.1

Our party consisted of one member of the Ministry of Fuel and Power, two members of the Department of Scientific and Industrial Research, one of these being from the Building Research Station and one from the Fuel Research Station. [0.2

We arrived in America in early December, 1944, and stayed 11 weeks in U.S.A. and one week in Canada. We found that the amount of information to be obtained was very considerable and we regret that owing to the vast size of the country we were unable to follow up a number of interesting, and probably useful, contacts which had been suggested. [0.3

We visited Boston, Washington (D.C.), Philadelphia, Chicago, Urbana, Seattle, Portland (Oregon), St. Louis, Lafayette, Columbus, Cleveland, Detroit, Pittsburg, Charleston (South Carolina), Norfolk (Virginia), New York and New Haven with a brief visit to Canada including Ottawa, Toronto and Montreal. The towns visited in U.S.A. were, therefore, mostly in the highly populated North-Eastern region where the winter climate is a great deal colder than in Britain, with temperatures often 30°F. or more below our levels. At Seattle and Portland, however, conditions throughout the year are almost the same as in London while in Charleston the winter is rather similar to that in the South of England, but the summer is much hotter. It is important to keep in mind this wide variation in climate of the different regions. [0.4

We visited many of the major research institutions of the various fuel associations, together with a number of research laboratories at universities and laboratories where appliances were being developed and tested. We also saw many architects and heating engineers, both officials and consultants in private practice. We met representatives, and visited the works, of a number of appliance manufacturers. In addition we visited houses in almost every town and inspected appliances in operation. Discussions with housewives proved a valuable method of assessing some of the advantages and shortcomings of the various appliances and systems of heating. In all we recorded over 150 interviews apart from the many unrecorded conversations which we had when visiting houses, works and laboratories. [0.5

In preparing this Report we have had in mind that it may be read by a variety of people some of whom would be interested mainly in a general picture while others would want technical detail. Those who only want the general picture may content themselves with reading Chapter 1 (General picture) and

Chapter 14 (Summary). Technical supporting data is given in the intermediate chapters and in the appendices. A list of people and places visited, literature obtained, and certain detailed information are given in the appendices. [0.6

One conclusion that stands out more strongly than any other is the importance of a large scale demonstration and experience of the different methods of heating the whole house. [0.7

Even in those areas of the United States where temperatures are comparable with those in Britain, the designer aims at providing heat continuously for the whole house and regards the open fire simply as a social luxury and perhaps an extravagant one at that. In this country there is already the beginning of a swing-over to this opinion. There is no longer any doubt that central heating in the British sense of the term is more efficient than individual fireplaces, and there has already been amongst high income groups of the population in Britain a strong tendency to demand central heating in their houses, where the open fire is relegated to the position of a luxury appliance and is not used as the sole means of heat. A similar development may be expected for all housing. [0.8

One of the chief difficulties we had in America was to produce a yard stick to compare running costs, and in some ways the figures we have brought back and shown in this report are misleading. Nevertheless if they are considered dispassionately and regarded simply as an indication and a background to the general picture they may be useful. [0.9

In the past there has been much comparison on a theoretical basis and the only way to settle the matter is to demonstrate on a large scale in a practical way by building an appreciable number of houses using various central heating methods and having the fuel consumption observed carefully. Fortunately, in view of the great shortage of houses the expenditure on demonstration houses that will be lived in would be useful expenditure. [0.10

We would like to record out thanks to all the people listed in Appendix 4 and to many others that we met but cannot name individually. Wherever we went we were given a most enthusiastic welcome and the greatest help. Everyone was most anxious to assist us and prepared to go to endless trouble to help Britain in the problems of post-war re-building. We would like to thank the many officials of the various Housing Authorities in Washington. It was largely through Mr. Jacob Crane, Urban Director of Housing of the National Housing Agency that we were able to meet various officials. We would particularly like to thank Mr. Robert K. Thulman of the Federal Housing Administration and Mr. Wadsworth of the Federal Public Housing Authority who gave up so much time to us and advised us so well who and what to see. We would also like to give special mention to Mr. Cyril Tasker, an old member of the Fuel Research Station and now Director of Research of the American Society of Heating and Ventilating Engineers. We also wish to record our thanks to Miss Onhauser, our Secretary, lent to us by the U.K. Treasury delegation; she travelled with us in America, and gave us most valuable assistance throughout our tour. We must also mention the valuable help given to us by Mr. J. B. Harris of the Directorate of Common Services, and his staff, by the Officers of the British Information Services and by the British Consuls in various cities. [0.11

Chapter I

A GENERAL PICTURE OF THE CLIMATE, FUEL SUPPLY, METHODS OF HEATING, APPLIANCES AND RESEARCH WORK

"*Ours is a lavish land. In contrast with the poverty general in other parts of the world, the life in any large American city seems wasteful in the extreme—the blaze of lights, the profligate consumption of gasoline in driving half empty cars, the abundance of food, the extravagant clothing, and the over-heated homes and offices. Much of this waste, however, is merely on the surface. The real enemy of abundant living is not so much visible as invisible waste. Because our homes are better heated than foreign homes it does not mean that Americans are extravagant. In fact a single central-heating unit may keep a whole house warm with less coal, or its equivalent in oil or gas, than our grandfathers burned in scattered fires in open grates that left chilly corners in every room.*"

GENERAL

1.1. The above quotation from an official publication gives some indication of the American scene.* The country contains immense natural resources and has been using these very extensively but not necessarily extravagantly considering the returns obtained in terms of a high standard of living. Before considering methods of heating it is necessary to understand something of the background conditions of climate, fuel supply and methods of living.

CLIMATE

1.2. In most of the areas we visited the winter climate is very severe and in many places this is accompanied by a hotter summer than we have, together with a considerably greater annual sunshine record. Winter temperatures of 30–40°F. below freezing are quite common and may last for a considerable time. The humidity in winter in some districts is much less than in England.

FUEL

1.3. The available fuels include bituminous coal over fairly wide areas, anthracite in a restricted region, mainly in Pennsylvania, fuel oil which is transported to most areas, natural gas which is piped for distances of more than a thousand miles, some manufactured gas and a little coke. Wood and sawdust are also used in some quantity in certain districts. Two-thirds of the electricity comes from steam stations and one-third from water power, but electricity is practically never used for space heating. It will be seen that natural gas and fuel oil and wood are available in quantity in addition to those fuels commonly used in Britain. Table 1 gives a general idea of the fuel usage for house heating in urban areas taking the country as a whole. It must be remembered, however, that owing to the vast size of the U.S. the local picture in any one place may be very different from this overall national view. For example in Los Angeles 90 per cent. of the heating is by gas, whereas in St. Louis 90 per cent. is by coal or coke. Details of the relative importance of different fuels are given in Chapter 4.

* Paul M. Tyler. Information Circular 7166, April, 1941. U.S. Department of the Interior.

TABLE 1

Heating Fuel used in Urban Areas of the United States

Type of Fuel	*Per cent. of homes using this type of fuel for heating*
Coal or Coke	65
Wood	6
Gas	16
Oil	13

TYPE OF HOUSE

1.4. Our impression is that on the whole the modern small house in U.S.A. is rather lower in space standards of habitable rooms than the pre-war British house. This is certainly the case in wartime houses which have been quite drastically cut in size, but we believe it is also generally true of their pre-war houses, a high percentage of which have not more than two bedrooms. On the other hand the heating and mechanical equipment of houses is on a rather more generous scale than here.

1.5. The house plan differs a good deal from our own, being much more open in the living area. Internal doors are left open, or, more usually, omitted altogether. Sometimes partition walls are dispensed with. There does not seem to be the demand for privacy to which we have been accustomed and this shows itself in various aspects of American life. It seems probable that this open planning is directly related to the methods and standards of heating and it certainly makes for freer air movement around the house. Once the idea of heating the whole house is fully accepted, then part of the need for doors and dividing walls disappears. This is an important factor to which we refer in some detail in Chapter 3.

1.6. Most of the modern small houses are detached dwellings and usually of single storey construction. Basements are traditional and, except in war-time houses, are still largely used. This has a direct bearing on the methods of heating as one of the commonest systems used will only function satisfactorily in a house with a basement. The implications of this are also dealt with in detail in Chapter 3, but it is necessary to emphasize here that the basement is never regarded as habitable space used for ordinary living purposes although it is of considerable value for occasional use for such purposes as clothes drying, games room or hobby space.

AMERICAN REQUIREMENTS FOR SPACE HEATING

1.7. Full heating of the entire house is taken for granted in all the regions where the climate is as cold or colder than England, even in houses of the lower income groups. The open fire is, in fact, quite useless as a major form of heating in their severe winter conditions. While the open fire is retained " for its decorative value " in the homes of the richer people, there does not seem to be any particular demand for it, or for any alternative, as a source of high temperature radiant heat. We wonder whether the large amount of sunshine obtainable throughout the year has any bearing on this apparent lack of demand for artificial radiation as compared with England.

1.8. The condition which the average householder seems to ask for and the average heating engineer tries to provide is that of a constant and even temperature throughout the house, or at least throughout the living and working areas with a slightly lower but constant temperature in bedrooms.

1.9. When asked what temperature they liked the majority of people said 70–72°F. with rather cooler bedrooms, but in actual fact we found that air temperatures were usually maintained rather higher at somewhere around 74–76°F. and they may have been even higher before the wartime fuel economy campaign came into force. Moreover very considerable efforts are made to reduce draughts and general infiltration of outside air. Except in the case of some bedrooms it was most unusual to find any windows open and air bricks or ventilators were never provided.

1.10. Some explanation of these conditions seems necessary and to some extent they are undoubtedly a direct result of the extremely cold outdoor conditions. The very cold external temperature results, even in an insulated house, in cold inner surfaces to the walls. Radiation of heat from people in the rooms to these cold walls makes it necessary to keep air temperatures rather high to compensate for the heat lost to walls. Then, too, the normal indoor dress is more or less the same in summer and winter. There may be something in the fact that because there is usually no visible source of heat there is a tendency to require a high temperature before people are convinced that they are really warm unless they can see a thermometer, whereas in England with an open fire it may be that we are more easily convinced that we are warm by the actual sight of the flames or glowing fire. The desire to reduce ventilation is quite understandable for the discomfort of outside air coming in at a temperature about 70°F. below room temperature as compared with about 30–35°F. difference in England can easily be imagined, and the waste of fuel in heating up an excess of cold air would be considerable.

FUEL ECONOMY AND THE AMERICAN ATTITUDE TO COMFORT AND CONVENIENCE

1.11. It seems to be recognised that neither in America nor Britain have fully satisfactory conclusions been reached on the actual requirements for optimum comfort and it is therefore clear that a further united effort by physiologists, physicists and engineers of the two countries should produce valuable results.

1.12. In spite of the long and very cold winters which occur in a large part of the most populated areas, the average fuel consumption for house heating for the whole of the United States is estimated to be only an equivalent of 4½ tons per annum per household. This average figure is, of course, difficult to interpret because of the range of climatic conditions and indeed there are so many differing factors that any real comparison with Britain is most difficult. However, the comparative efficiencies of heating methods in the two countries are so strikingly different that at the risk of some incompleteness and possibly even mis-interpretation we give in Table 2 some isolated facts on fuel consumption which we obtained in a few places. Perhaps the most useful of these are the figures for Portland which has a climate only very slightly colder than London ; here the houses are heated for an average of 4½ tons per annum of coal or equivalent fuel. This is not very different from the quantity used in Britain but instead of heating a small part of the house for part of the day only to a temperature of about 65°F. the houses will almost all have been heated to over 70°F. throughout the entire house for 24 hours of the day. There must obviously be a considerable difference in the efficiency of the methods adopted in the two countries. It has been estimated by R. K. Thulman, Chief Mechanical Engineer of the Federal Housing Administration, that the average working efficiency of American house heating appliances is probably about 45 per cent.

1.13. This result is obtained by the use of more economical systems of heating than we have been used to, though economy of fuel seems to play a comparatively small part in more recent development work. Conditions of extreme cold have forced the Americans to obtain an adequate quantity of heat, and having reached a stage when this can be provided reasonably economically they are now devoting most of their energies to improving the convenience and comfort of heating systems. The demand for labour-saving methods leads to the elimination of solid fuel appliances from living rooms to avoid the dirt caused by them, and then, with increased income or standard of living, to the use of automatic firing of furnaces either by automatic stokers or by changing to gas or oil fuel. The same demand for cleanliness also leads to the use of forced warm air distribution which can include dust filters ; comfort and convenience is also improved by the use of thermostatic control. While all these improvements are not at present common in houses for the lowest income group there is a definite trend in this direction and we feel that it is important to recognise this as being the kind of demand which has to be met once an adequate amount of heat has been provided at a reasonable price. Another labour-saving detail is that in many areas electricity meters are placed outside the houses to facilitate reading by the Supply Company representatives. Reference may also be made here to the system, described in Chapter 2, in which individual house meters for gas and electricity are eliminated and an unlimited supply of these fuels for cooking and water heating is provided at a standard charge which is included in the rent.

1.14. The same attitude towards comfort is noticeable in relation to the provision of heat insulation in walls and roof and by double windows. Although it is realised that by using heat insulation annual fuel costs are reduced, people also appreciate very fully the fact that they are making their homes much more comfortable and it is often the comfort rather than the fuel saving which they stress most.

1.15. Humidity is another condition which is different. Whereas in Britain some heat throughout the house is required in order to keep the structure and contents in good condition and free from dampness, in some districts of America humidity is sufficiently low to cause attempts to be made to increase it by artificial means. This then leads to problems of condensation of moisture on the inside of windows and outer walls owing to the extreme cold outside. Fortunately this latter trouble is not likely to be serious in this country if we provide full house heating or even some "background" heat, i.e. a small amount of heating throughout the house, together with reasonable insulation of the structure and take steps to reduce the penetration of moisture into the structure when composite wall panels are used.

TABLE 2

Isolated Examples of Quantity of Fuel Used for Space Heating

City	Climate		Lowest recorded winter temperature °F.	No. of dwellings	Method of Heating	Equivalent coal used per annum in English Tons	Notes
	American Degree Days for district	Av. Jan. Temp. °F.					
St. Louis..	4,610	31	−22	*	Various hand-fired appliances.	5½–6½†	* Average taken from Survey of City. † Probably some water heating included. Does not include cooking.
Portland ..	4,379	39½	−2	1,000	Space Heaters placed in Living Rooms.	4½	Heating only.
New Kensington	5,466*	31	−20	250	Forced warm air from gas furnace.	5½†	* May be higher as actual site very exposed. † Includes cooking and water heating.
Cleveland	6,171†	26½	−17	620	Hot water heating to flats and houses from Central Estate Plant.*	5	† An exposed lakeside site. * Includes h.w. supplies but not cooking.
U.S.A. ..	Global figure for whole country ..					About 4½	
Britain ..	Global figure for whole country. British Degree Days about 4,000.					4* (about)	*Excluding coal used for domestic gas and electricity.

Notes.—Average January Temperature for London is 41°F. Lowest recorded Temperature is 4°F. and Degree Days are 3,750.

American Degree Days are on a 65° temperature basis.

British Degree Days are on a 60° temperature basis.

[A " Degree Day " signifies one degree below the temperature basis (i.e. 65°F. in America and 60°F. in England) throughout the period of 24 hours. For any one day there are as many " Degree Days " as there are degrees Fahrenheit difference in temperature between the average outside air temperature, (taken over a 24-hour period) and the degree day base temperature. The annual total of " Degree Days " is the sum of " Degree Days " for all the days in the year.]

HOUSE HEATING

WARM AIR METHODS

1.16. Except in the South where little heating is needed, a very large proportion of the small houses in all areas are heated by some form of warm air heating. Very occasionally a combination cooker and space heater is used but nearly always a separate apparatus is used for space heating. There are four main systems of warm air heating in common use :—

(*a*) Space heaters placed in the living room.

(*b*) Pipeless warm air furnaces.

(*c*) Gravity warm air through ducts.

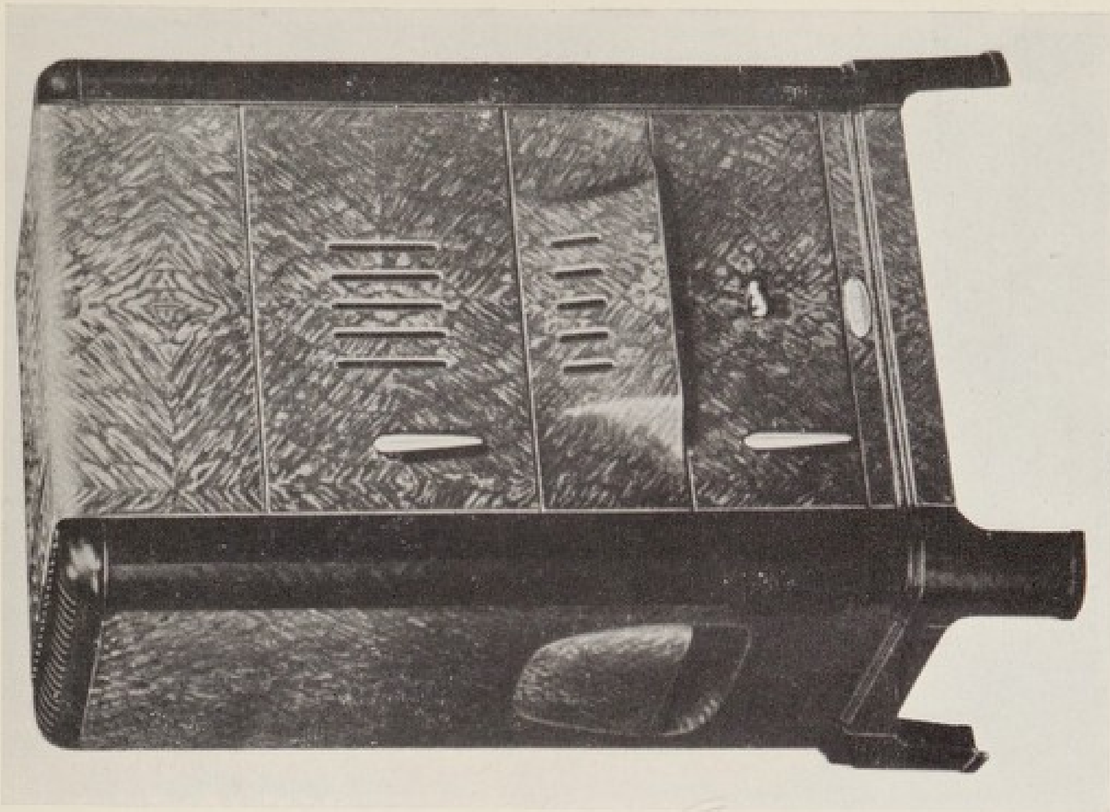
(*d*) Forced warm air through ducts.

These are briefly described below and more details are given in Chapter 7. It may be taken that space heaters and pipeless warm air furnaces represent the least satisfactory but cheapest methods. Gravity systems are in fairly general use in small houses, but forced warm air systems are more expensive in first cost and although increasing in use are not yet really common in the smallest homes.

1.17. *Space heaters.*—These are placed as far as possible in a central position in the house, almost always in the living room, and consist of a large free standing stove, usually with an outer jacket. Heating is mainly by convection, air entering and leaving through grilles in the jacket. The stove or space heater is connected by a sheet metal flue pipe, usually to a brick chimney. The heater may be fired by solid fuel, gas, oil or wood, according to the prices ruling in the district and to the income of tenants but the majority are coal or wood fired.

1.18. The initial cost of this type of heating is low and running cost appears to be comparable with other methods. In order to warm the whole house from one heater it is necessary to have easy circulation of air from the living room to all parts of the house. In a single-storey house, doors to bedrooms will usually open from the living room and the warm air will pass through them ; in a few cases there may be grilles in walls between living room and bedrooms on the ground floor. The typical plan of the small modern house of two-storey construction achieves this circulation by omitting the entrance hall and placing the stairs in the living room. Warm air rises up the stairs and enters bedrooms through the doorways. Federal Housing Administration limit the use of space heaters to single-storey houses, but in other housing it was fairly common in two-storey work.
In some districts of Canada a metal flue pipe from the space heater is taken through several rooms before finally rising through the roof. This flue thus gives up almost all its heat to the house.

1.19. On the whole it is probably true to say that the majority of people having space heaters are moderately satisfied with them, but they mostly realise that they are by no means ideal and when questioned express a desire for either duct-circulated air heating or hot water radiators. We believe that except for the wartime houses this form of heating is now seldom installed in new buildings, although there are still something like 35 per cent. of all existing urban dwellings and a higher proportion of rural dwellings



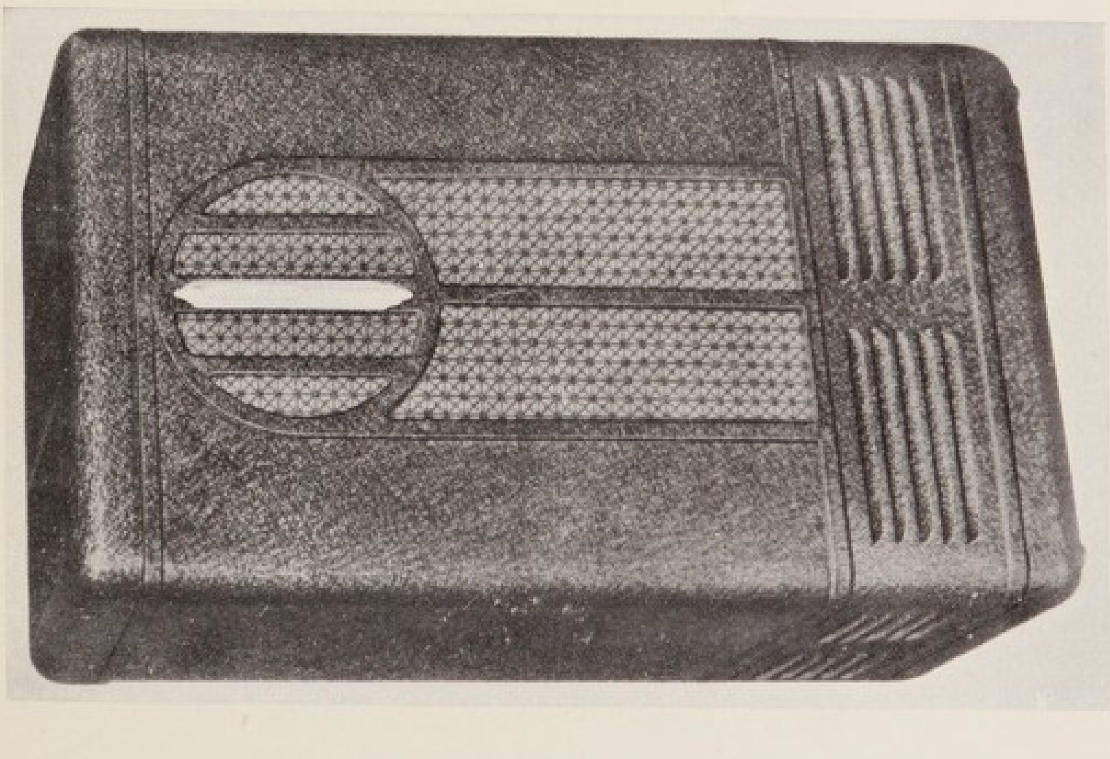
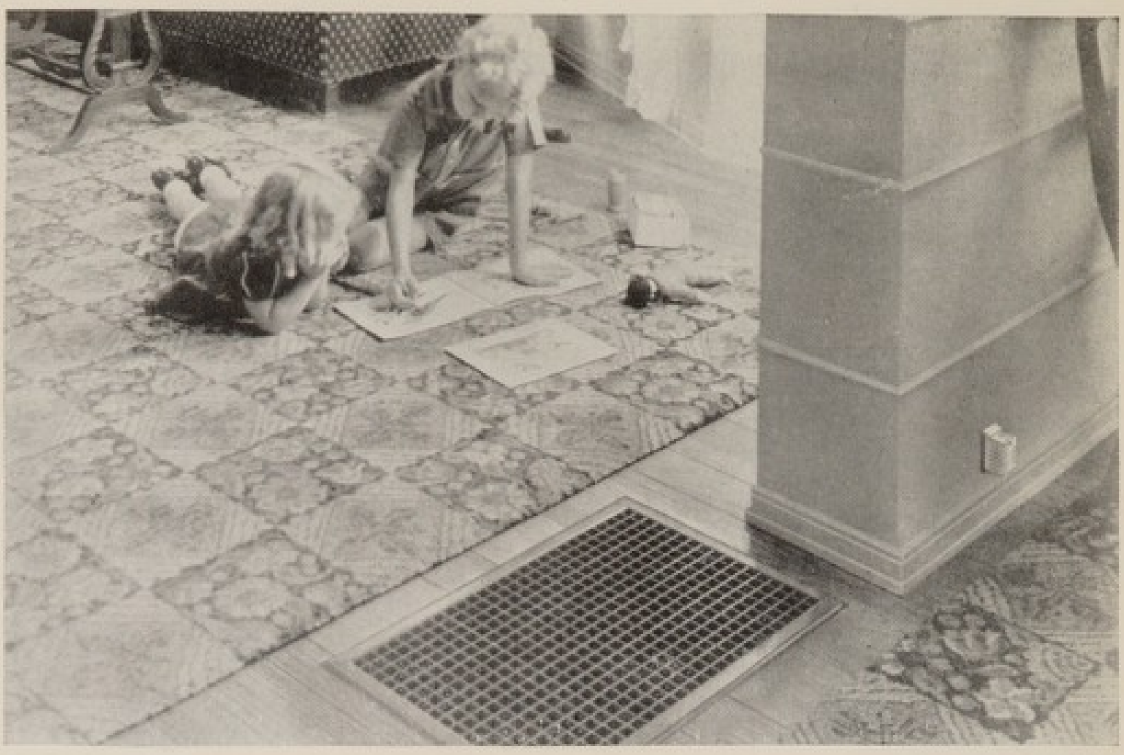


Fig. 1. Typical Space Heaters.



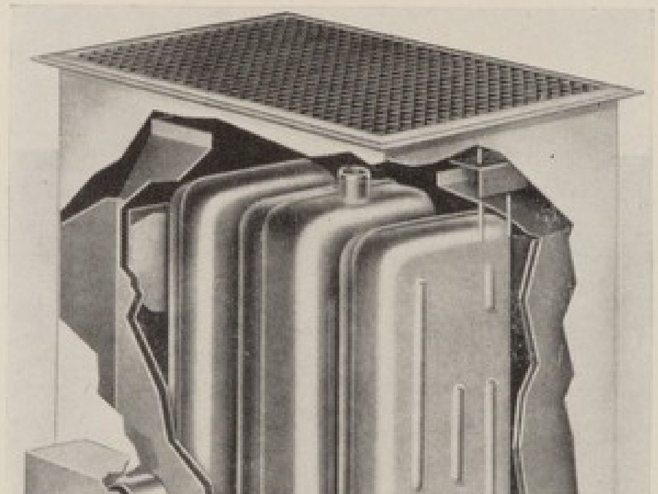


FIG. 2. Typical Floor Furnace.

heated in this way. The disadvantages of this system are, first, the bad distribution of heat. It will be too cold at floor level and too warm at ceiling level. We frequently found temperature gradients of 12–15°F. and sometimes more, between floor and ceiling. "The cold seventy" was a common expression used to describe the floor conditions when the air temperature at a height of 4–5 ft. was 70°F. This type of heating is only suitable for a compact plan with the heater near the centre and it is essential to have an open plan or to leave doors open. This latter point does not seem to be considered a drawback in America. Floor draught is often complained of with this type of heating but we believe that it was floor coldness rather than actual draught which was the real cause of discomfort. By far the commonest complaint, however, was of the dirt caused by carrying solid fuel into a living room and removing ashes. Almost everyone objected to doing this. There is a slight tendency to dirtying of the ceiling over the heater but this is not serious. Thermostatic control is not provided, with the result that overheating frequently occurs.

1.20. It is curious that practically no heaters of this kind are made as openable stoves. Some direct high temperature radiation might help to overcome the cold floor troubles. In some models an electric fan was incorporated in the heater to force air across the floor and this would result in better heat distribution. Presumably it would also stir up a good deal of dust from the floor unless the velocity is very low.

1.21. The heater plus jacket was always a good deal larger than the closed stove as we know it in this country. The outer jacket is of sheet metal, enamelled in various colours and designed to have what was called a "popular appeal". Two typical examples are illustrated in Fig. 1 (p. 7).

1.22. *Pipeless warm air heaters*.—These consist of a heater, either placed immediately below the ground floor in a small pit and fired by gas or oil, in which case it is called a Floor Furnace, or of a heater placed in the basement and covered with a jacket which delivers warm air through a grating in the floor immediately over the furnace. In either type warm air rises through the grating in the floor to the living room and then finds its way throughout the house in much the same way as in the case of the space heater, but owing to the greater "head" it gives rather better heat distribution in the living room. As with space heaters there is re-circulation of the same air, the return to the heater being around the edges of the outlet grating.

1.23. This method of heating is less common and on the whole rather less liked than other methods. Disadvantages are much the same as with space heaters and one imagines that a considerable amount of dirt and dust must find its way through the floor grating and that at least some of this will be carried up again by convection currents. Although it was claimed that gratings were removable and cleaning could be done quite easily we doubt whether such cleaning was often done or that it was always possible. An advantage of this type of heater in a small house is that it does not take up any floor space other than the area of grating which must be kept clear of furniture or floor covering. Fig. 2 (p. 8) illustrates a heater of the Floor Furnace type. Sometimes instead of the grating in the floor there is a double grating placed in the bottom of a partition dividing two rooms so that the furnace warms two rooms which may in that case be divided by doors.

1.24. *Gravity warm air furnaces.*—The apparatus consists of a furnace, fired by solid fuel, oil or gas. Air is heated and is circulated by gravity through a series of ducts, usually to every room in the house. Sometimes for bedroom warming there may be only one duct to the landing of a two-storey house with distribution to bedrooms by infiltration through doorways. Often there will be one main return duct from a grating in the ground floor or on a wall near ground floor level. All the air is, therefore, re-circulated and there is no fresh air introduced except by infiltration. For efficient operation there must be a fair difference in level between the furnace and the lowest outlet and, since for reasonable heating the outlets need to be at or near floor level, it follows that this system can only be used satisfactorily with a furnace placed in the basement. Ducts are usually of galvanised iron and the smallest size delivering to one opening about 10 in. by 3½ in. It is most important that the duct sizes are properly calculated and designed, otherwise the system may be very unsatisfactory. Thermostatic control is fairly frequently included. Figure 3 (p. 11) shows in diagrammatic form this type of installation.

1.25. On the whole this system gives reasonable satisfaction although there may still be quite large differences in temperature from floor to ceiling. Dirtying of wall decorations over inlet gratings was noticed in a number of cases and seems to be difficult to avoid. How dirty the ducts get and to what extent they are cleaned is difficult to estimate. There are firms who undertake duct cleaning, but it seems doubtful whether anything is done in the majority of houses. Absence of dirt and dust in the furnace room is said to make a considerable difference to the amount of dirt carried into the house but on the whole the consensus of opinion seemed to be that this system does result in a fair amount of dirtying of household furniture and decorations as compared with forced warm air heating with filters or hot water radiator heating, although neither of the latter is free from fault in this respect. We heard of a number of complaints of oil staining when an oil fired furnace was used. Gravity warm air heating is very widely used in low rental houses. We were given figures which show that in urban areas some 22 per cent. of dwellings are heated by either gravity or forced warm air furnaces. These figures did not indicate the relative proportions of the two systems at present in use, but figures from a 1940 survey of *new* houses indicate that about 20 per cent. have gravity systems and 20 per cent. forced warm air systems.

1.26. *Forced warm air heating.*—This consists of a furnace, fired by solid fuel, gas or oil, heating warm air which is circulated to the rooms by ducts. Circulation is by means of an electric fan placed on the inlet side of the heating chamber. Figure 4 (p. 12) illustrates in diagrammatic form this type of installation.

1.27. With this system there are almost always return ducts from each room. Outlets are usually at low level and inlets are preferably at low level except with continuous fan operation. With forced circulation the use of dust filters is possible and these are in fact usually provided.

1.28. Forced warm air systems, if properly designed and installed, generally give a more even temperature distribution than the gravity systems. They are usually considered to be cleaner than gravity systems because of the use of filters although, in fact, the filters do not remove the finer dust particles. Presumably a forced air inlet at low level creates a considerable amount of dust disturbance across the floor, but there were practically no complaints about this. This type of heating is appreciably more expensive in first cost than the gravity system in spite of the fact that the duct sizes can be smaller. It is, therefore, seldom provided in houses of the lowest cost, although its advantages are now being recognised to the extent that it is being installed in an increasing proportion of speculative building. A number of authorities believed that if it was generally installed in low cost public housing there would have to be some provision for adequate maintenance of the filters because even in larger houses there was a tendency to neglect cleaning or replacement. Thermostatic control is generally provided; it is often on the intermittent principle but modulated control is being developed.

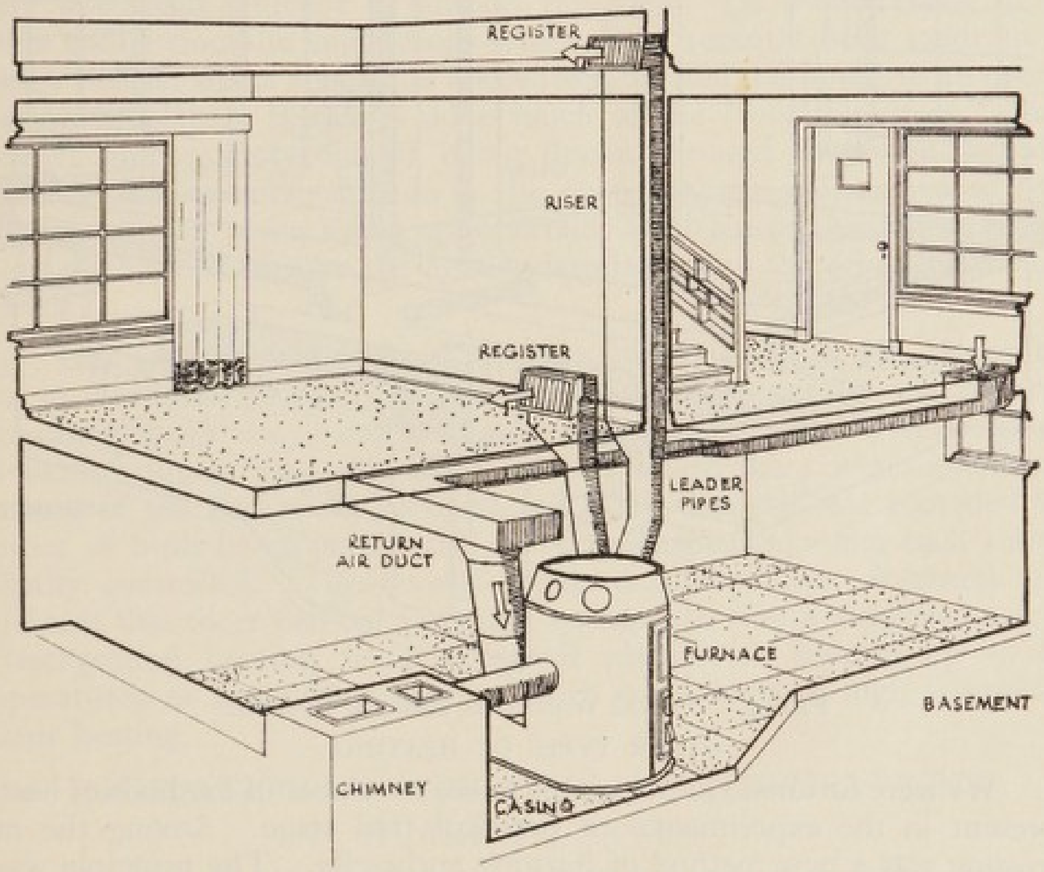


FIG. 3. Gravity Warm-Air Heating System.

HOT WATER OR STEAM RADIATORS

1.29. About one-third of all types of urban dwellings are heated by steam or hot water, but the majority of this is accounted for by flats and larger houses and to some extent by District Heating or Group Heating. There is at present only a small proportion of low cost individual house heating of this kind. For individual houses hot water is almost always used in preference to steam and heat transfer is at present by normal types of radiator although experiments with skirting board radiators are now in progress.

1.30. The first cost of a hot water radiator system in a medium sized house appears to be roughly similar to the cost of a forced warm air system. With radiators under windows trouble from dirt staining does not occur and the general opinion appears to be that this form of heating is convenient and clean. Some installations have been made using forced water circulation with small piping. There is some difference of opinion about the merits of this and at present not enough evidence to draw any conclusions. On the whole it seems that opinion is against it for small houses, but more in favour for flats or group heating. One of the advantages of the small pipe and forced circulation is the quicker response to changing demand.

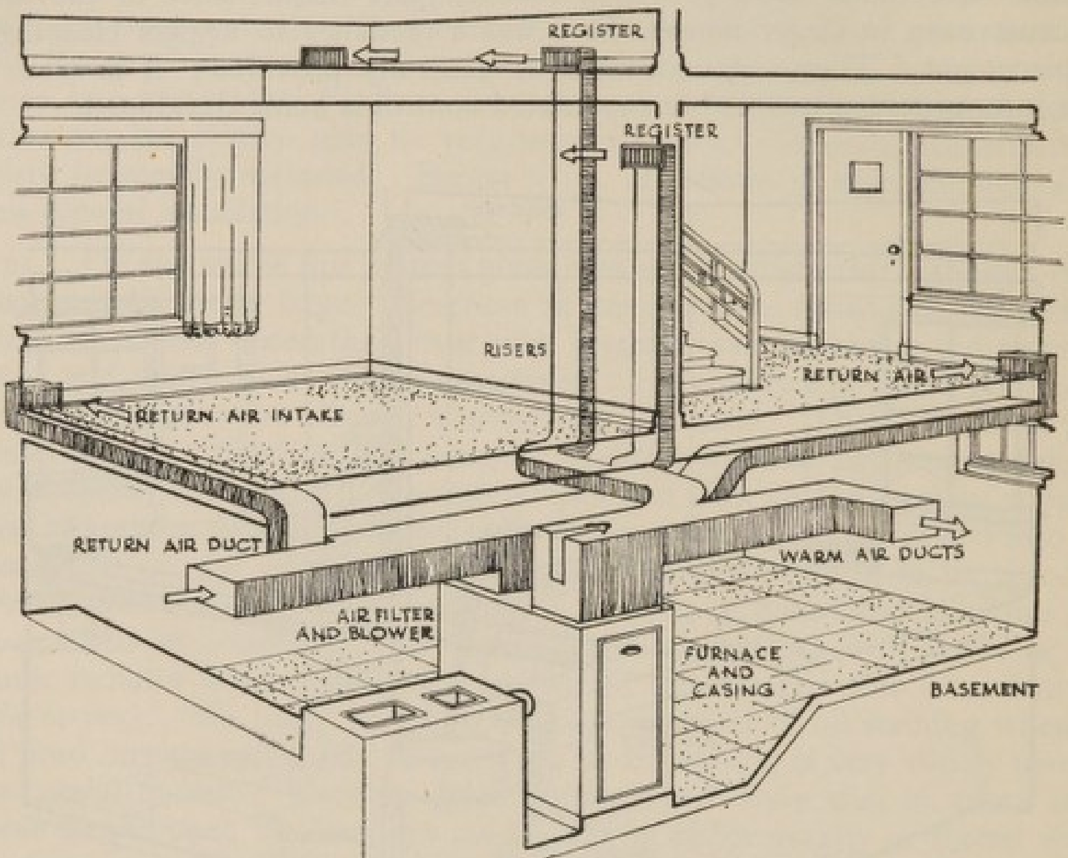


FIG. 4. Forced Warm-Air Heating System.

OTHER TYPES OF HEATING

1.31. We were fortunate in being able to see a number of methods of heating at present in the experimental or practical trial stage. Among the most interesting was a new method of burning anthracite. The principle was to burn a small amount of fuel intermittently at high speed as opposed to normal practice of burning a large amount at low speed. Other interesting development work was being done on the adaptation of very small airplane heaters to domestic use. If this proved successful, the chimney, as we know it, could be eliminated. Chimney furnaces were beyond the early experimental stage and so were some forms of panel heating. Of the latter we saw examples of flats with floors and ceilings heated by warm air. These and other methods are described in more detail in Chapter 8. There appeared to be a very live interest in the whole subject and many ideas were being tried out. Quite a number of these were installed in houses coming within the control of the housing authorities and these authorities appeared to be very willing to encourage such experimental work.

HIGH TEMPERATURE RADIANT HEATING

1.32. Reference has been made to the absence of open fires except for decorative purposes. The fact is that they simply cannot provide the heat requirement. Some attempts have been made to popularise a type of open fire incorporating convection heating. These are described in Chapter 8, but they are not often used as the only source of heat except in small week-end cottages or sometimes in very mild climates. Even in Charleston (S.C.) where the climate is more moderate and the habits of the people are conservative, the open fire is disappearing in favour of more labour-saving methods of heating. Where the open fire is used for decorative effect the fuel is usually wood. A number of people suggested that in the really cold weather the lighting of an open fire caused a draught up the chimney which in turn caused cold outside air to be drawn into the house with a result that the air was cooled and the thermostat caused more fuel to be burned in the main heating furnace. The fire in other words acted as a cooling device. There was some evidence to support this view. (It is interesting to note in this connection the suggestions which have recently been made in this country that air ducts should be taken from outside the house to an opening near the fireplace. If this is done much of the "cooling effect" due to excessive amounts of cold air being drawn through the room would be avoided.) The general attitude to the open fire was well expressed by an architect who on being asked why certain small houses had two chimneys explained that one was for the heating appliance and the other for the open fireplace !

1.33. Gas and electric radiant fires are hardly used at all. Exceptions were in Portland (Oregon), where we saw an attempt by the electricity authority to make use of surplus power by popularising it for house heating and in the South, *e.g.*, Charleston (S.C.), where there were considerable numbers of gas fires. At Portland full house heating was provided by a number of built-in radiation and convection electrical units each thermostatically controlled. The results appeared satisfactory. It struck us as significant that there had not been any attempts to obtain a moderate degree of background heating from a central plant with topping-up to high temperatures as and where required with some form of high temperature radiant heating.

INSULATION—VENTILATION—CONDENSATION—HUMIDIFICATION

1.34. There is no doubt whatever that in the colder areas the value of a well heat-insulated house is now appreciated by the general public as well as by technicians. Just how much insulation it is economical to have does not seem to have been properly established though the amount provided does vary with climate, *e.g.*, between Chicago and Seattle. The comfort value of insulation, quite apart from any economic value which it may have, is recognised as most important. For the most part it seems that designers tend to rely upon the manufacturers of insulating material to guide them on the amount to use. The situation is somewhat complicated by the fact that roof insulation is often provided to keep out summer heat. On the whole it seems that although the idea of heat insulation is well established, at least in the cold regions of the country, the amount of insulation used where winter temperature is like ours is not very different from that of our own pre-war houses. Where the use of insulation is considered only just worth while it is first added to the ceilings of the upper storey. This may partly be in order to reduce summer temperatures and partly because with the entire house being heated the biggest heat loss is through the roof.

1.35. Double windows in permanent frames are unusual in small houses and removeable storm sashes were not found to anything like the extent we had imagined might be the case although where some people had fixed them recently in response to the appeal for fuel economy they claimed markedly increased comfort and appreciable fuel saving.

1.36. The whole tendency is for the Americans to make their houses increasingly airtight in construction and to reduce the inlet of very cold outside air to a minimum—(having experienced some of their really cold external conditions we appreciate the need for this). For calculation purposes one air change per hour is assumed, but actually it is probably less in many houses. We spent a number of evenings and some full days in various private houses and we were unable to find any evidence at all of stuffiness and staleness of the air and were convinced that from the point of view of comfort their conditions of ventilation are satisfactory. We believe that the open type of plan with the consequent large volume of air available and probably better circulation of air may be the reason for this freedom from stuffiness.

1.37. The very dry winter atmosphere has resulted in the provision of some attempt at humidification in the rather better installations. Our general impression was that while there was a desire for this, the householder could seldom be bothered to give it the necessary small amount of attention to keep it working.

1.38. The very cold outdoor conditions lead to a considerable amount of condensation on windows and some on walls. This combined with the desire for humidification seems to be an awkward problem as the more the air is humidified and the tighter the construction is made the worse the problem of condensation becomes. In houses of frame construction with insulating material in the cavity wall space it is found necessary in colder areas to prevent moisture from the house passing into the wall. This is done by providing a moisture proof layer, known as a vapour barrier, near the inner face of the wall.

HOT WATER SUPPLY

1.39. An outstanding feature is that a large number of old houses and almost all new houses have an adequate piped supply of hot water. This is usually provided by a separate water heating apparatus and a well lagged storage tank of about 25 Imperial gallons capacity. Occasionally, however, the water is heated from the main heating furnace or possibly from a solid fuel cooker. Some 70 per cent. of the separate water heating appliances are gas fired and only a very small proportion, about 4 per cent. are electric.

1.40. In quite a number of recent estates hot water is supplied at a fixed charge, either from a central supply in the case of flats or by an unlimited supply of fuel being available in return for a fixed charge included in the rent.

We give in Appendix 2 a summary of figures showing actual hot water consumption in houses with or without fixed charges and these show that while the unlimited supply results in an increased usage there seems to be a fairly definite upper limit to this. The respective averages per household per day are something like 35 and 50 Imperial gallons. Against this extra consumption must be placed the elimination of meters, of meter reading, office accountancy and collection of separate payment in addition to the improvement in amenity provided by the unlimited supply of hot water. It was said that on balance the system had justified itself.

COOKING

1.41. In urban districts about 75 per cent. of cooking is by gas and only 5 per cent. by electricity, and although there is said to be a fairly marked recent increase in electricity in certain cases there does not seem to be such intense competition as in England as on the whole gas prices are considerably lower than electric. A few solid fuel cookers, all free standing, were seen but, in our opinion, they were usually not as good as modern British types. We refer in Chapter 4 to methods of sale and maintenance of apparatus and in Chapter 10 give more details of cooking appliances. The chief differences we noted from British practice were first that appliances were always bought and never rented. Secondly they seem to be more guided by fashion and are not constructed so solidly. They tend to be designed for speed in performance rather than for economy. The oven is generally at a higher level than in British cookers, and the grill is always in or under the oven and not on the top plate.

RESEARCH WORK–TESTING–STANDARDISATION

1.42. While we were very impressed with the total amount of research work in progress, it appeared that there was a great concentration of effort on problems of immediate practical application. We noticed that a considerable amount of the work going on, even at universities, was directly sponsored by trade interests. Our general impression was that there was rather more work being done on methods of heating than on actual heating appliances and we noted the amount of work on heating being done in controlled rooms and complete houses. We felt that there was, perhaps, some lack of a central organisation to co-ordinate the very large mass of work in progress in the many laboratories we visited and we found that at times it was difficult to discover where certain research work was being done.

1.43. Testing of appliances is done by a number of Institutions and it is important to note that the Housing Authorities have made and are making considerable use of the facilities of the Bureau of Standards and other recognised testing authorities for testing appliances under consideration for housing projects. Special mention should be made of the American Gas Association. In many towns gas appliances can be installed only if they conform to the test requirements of the A.G.A. This has undoubtedly had a beneficial effect on the quality of appliances, although a continuous effort is required to improve the standards which some people criticise as being too low. Numerous associations and institutions are busy on the provision of Standard Specifications. Individually these specifications are often excellent but the lack of a single authority to deal with the preparation of all standards results in a certain amount of confusion.

ATMOSPHERIC POLLUTION

1.44. In a number of cities there is a very real awareness of the evils of atmospheric pollution and a determination to take action. The outstanding example is St. Louis which was by general consent recognised as the dirtiest city in the United States and which, by very drastic action, has been converted in a really remarkable way. We describe the St. Louis case in some detail in Chapter 5.

FLUE CONSTRUCTION

1.45. It is common practice, and in some cities compulsory, to line new brick flues with a glazed tile or pipe. Apparently this treatment developed as a precaution against fire risks, but it is also found valuable where gas fired furnaces are used since brick flues are unsatisfactory with this type of appliance. Old brick chimneys are sometimes re-lined as a precaution against deterioration due to gas furnaces and a type of enamelled iron pipe was developed for this purpose. This may also be used, sometimes as a double pipe with heat insulation between, for new flues without any brick surround. We describe these and other types of chimney in Chapter 12.

GOVERNMENT CONTROL BY HOUSING AUTHORITIES

1.46. To conclude this general review we give some idea of the central Government control. Between 1933 and 1942 a series of Government Agencies had been set up to deal with housing problems in the United States. Many of these agencies were aimed primarily at solving problems arising out of the great depression and date back to 1933. They were often designed to stimulate house building and repair on the one hand and to prevent mortgage bankruptcies on the other. In 1942 the National Housing Agency (N.H.A.) was formed to co-ordinate and control and bring under one umbrella many of these activities. Besides purely financial agencies such as the Federal Home Loan Bank Administration and the Defense Home Corporation it now includes two housing agencies :—

(1) Federal Public Housing Authority (F.P.H.A.)—provides loans to local authorities throughout the States for the provision of houses to be let on rentals.

(2) The Federal Housing Administration (F.H.A.)—which insures private mortgages. This covers all kinds of private house development up to a value of about the equivalent of £4,000. (1938 values).

1.47. It will be seen, therefore, that the F.P H.A. deals with what we call local authority housing. The F.H.A. on the other hand has no counterpart in this country. Perhaps one of the chief contributions that this Department has made is in its power to influence a steady improvement in building practice. The fact that they guarantee loans gives them the power to demand a certain standard of quality of performance in return and it is through this power they are able to influence the general standard of efficiency in the heat installation.

1.48. The N.H.A. itself, the F.P.H.A. and the F.H.A. had technical departments of their own and since from British experience it was likely that each agency would look at the heating problem from its own particular angle, we made a point of discussing our problems with these experts separately and together and to avoid spending our time exclusively with any one of them. The N.H.A. deal with the housing needs of the population and, as far as heating is concerned, with general basic principles on how best to meet these needs, whereas the F.H.A. and F.P.H.A. were more concerned with their day-to-day application. The F.P.H.A. are concerned with methods of providing heat that are sound and reliable and of the lowest possible cost and they were invaluable in helping us to obtain information on running costs in a number of housing projects where the heat installation was provided as a part of the rent. F.H.A. on the other hand, dealing as they do with rather higher-priced houses were able to take an interest to a rather greater extent in new developments, and we drew very largely on their knowledge and experience of these new developments. We found that although the F.P.H.A. had a full appreciation of the importance of reducing annual costs for fuel even at the expense of additional capital outlay they were to some extent handicapped by an overall capital cost limit imposed by wartime Senate legislation. Thus, it was difficult for them to approve a proposition which appeared to be financially and socially desirable if it increased first cost beyond a certain sum.

1.49. Each agency has local representatives in most cities co-operating with the City and Local housing authority and whenever we had occasion to visit their offices, as we usually did, we found their generous help invaluable. Apparently, there had been a certain amount of feeling in some localities that to begin with there was too much " interference " from the central authorities and, as a result of this, advice is now given from the centre but the value of local knowledge and custom is allowed to play a greater part.

GENERAL

1.50. We hope that in this Chapter we have been able to convey a general idea of the heating situation as we saw it in the United States. A summary of our conclusions is given in Chapter 14.

1.51. Climatic conditions and other factors are so different that it is not to be expected that any particular American heating system would be immediately applicable in this country but we are convinced that there is much to be learnt by a study of their methods.

1.52. We would also like to mention that although in some ways American installations are in advance of ours, we feel that British practice is in advance of American in certain respects. We were able on a number of occasions to give some information which American technicians found interesting. We feel certain that provided action is subsequently taken this exchange of ideas in both directions is extremely valuable and we hope that the making of a large number of personal contacts will facilitate a continual exchange of ideas. In this connection we would personally very much like to see a return visit of U.S. technicians to this country.

Chapter 2

BACKGROUND CONDITIONS OF CLIMATE, HEAT DEMANDS AND FUEL SUPPLIES

TEMPERATURE

2.1. In order to get a satisfactory background to heating requirements in the United States it is essential to appreciate the variety of climatic conditions throughout the country from extremely cold conditions in the North where the temperature may be below zero for many weeks during the year, to conditions in the South where in some districts no heating is required at any time. Great concentrations of population have grown up in the cold north, consequently the development of heating methods has been considerably influenced by the climatic conditions in those regions. Not only are the winters there much colder than in Britain but the summers are much hotter; also the transition from winter to summer is more rapid so that there are only brief periods in the spring and the fall when a comparatively small input of heat into houses is required. The average monthly temperature for five of the cities visited are shown in Fig. 5 (p. 19), and for comparison similar figures are shown for five places in Britain. The extreme conditions in Chicago are very noticeable but equally striking is the close similarity between the temperatures in Seattle (Washington) and London. Degree day figures (on the American basis of 65°F.) for all the cities visited are shown in Table 3, but these must be regarded with considerable care because it is stated that there are certain places in the U.S.A. where the degree day figure may be as low as, for example, 1,390 in Los Angeles as compared with 6,287 for Chicago, but where some degree of heating is needed on almost every day of the year because of the cool evenings. Table 3 also shows the mean January temperatures for the cities visited. An incidental result from these low temperatures is the depth of frost line which determines the depths of foundations of houses and influences the economy of providing basements. This is dealt with in more detail in Chapter 3.

HUMIDITY

2.2. Another important climatic factor is the amount of moisture in the air; this is usually quoted in terms of relative humidity but in order that the true significance of such figures may be understood it is necessary to elaborate. If the relative humidity of the air is 60 per cent. when the temperature of the air is 0°F. it means that at that temperature the air is holding, in the form of invisible water vapour, 60 per cent. of the amount which it can hold at that temperature. If this air is now heated to 70°F. as may happen when it enters a building it becomes capable of holding much more water vapour, consequently the relative humidity now becomes about 9 per cent. Because of this complication it is difficult to make an easy comparison of the amount of moisture in the air unless the comparisons are made at the same temperature. Consequently in order to give a comparative picture of the humidity in U.S.A. and Great Britain the data given in meteorological records have been adjusted so as to show the humidity

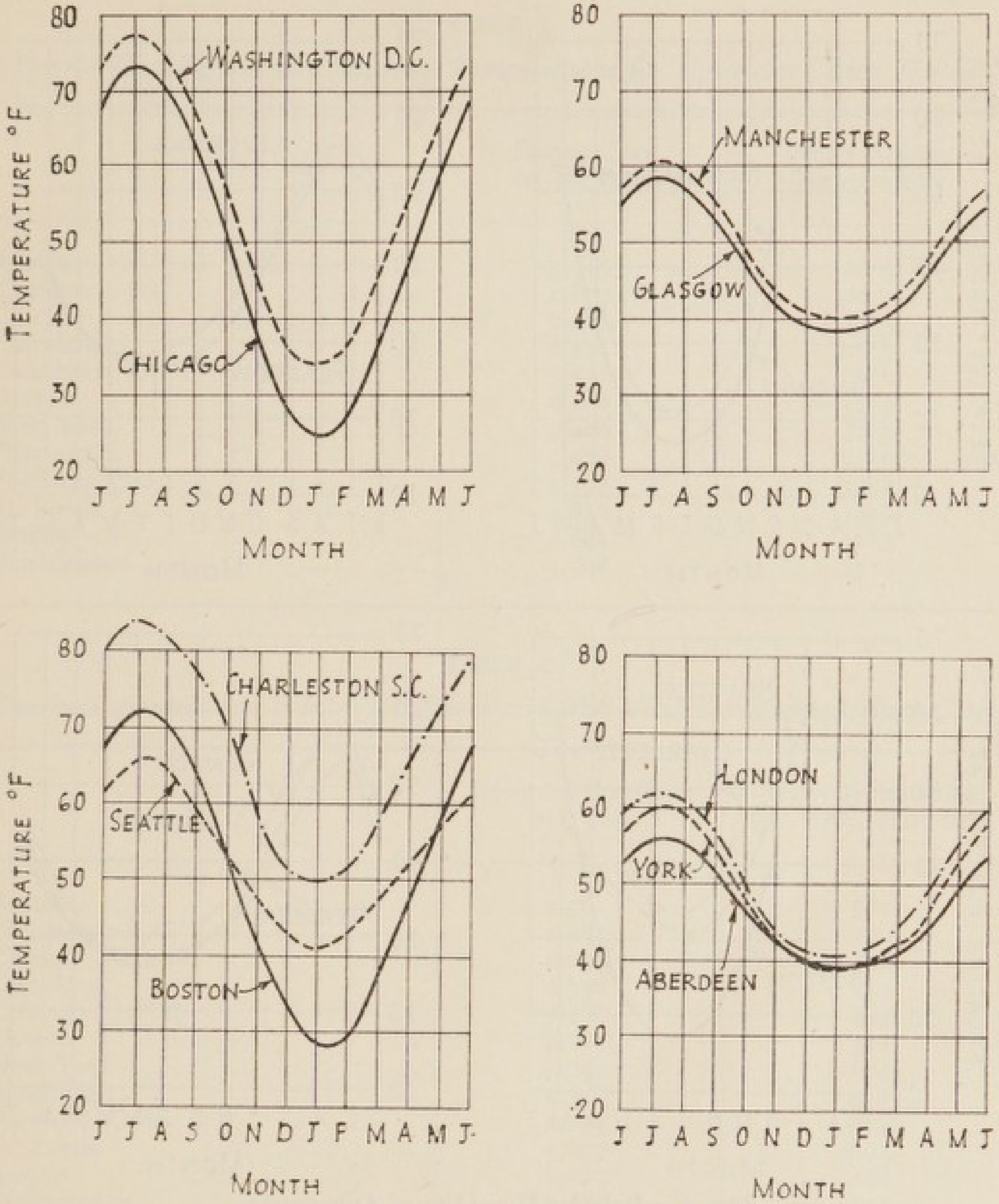


FIG. 5. Mean Monthly Temperature for five U.S.A. and five British Cities.

at a temperature of 70°F. The results are shown in Fig. 6 (p. 20). It should be remembered that in all cases actual humidities measured indoors at 70°F. will be higher than this value because of the moisture given off from the human body and from cooking, etc. From Fig. 6 it will be seen that in the winter the humidity is very much lower in the colder part of the States than in Britain but it will be seen that conditions in Seattle (Washington) and London, England, are almost identical. The humidity is so low in some areas that it is quite common experience to generate enough static electricity when walking in a carpeted room to draw a considerable spark on touching a metallic object as when unlocking a hotel door. Such varying

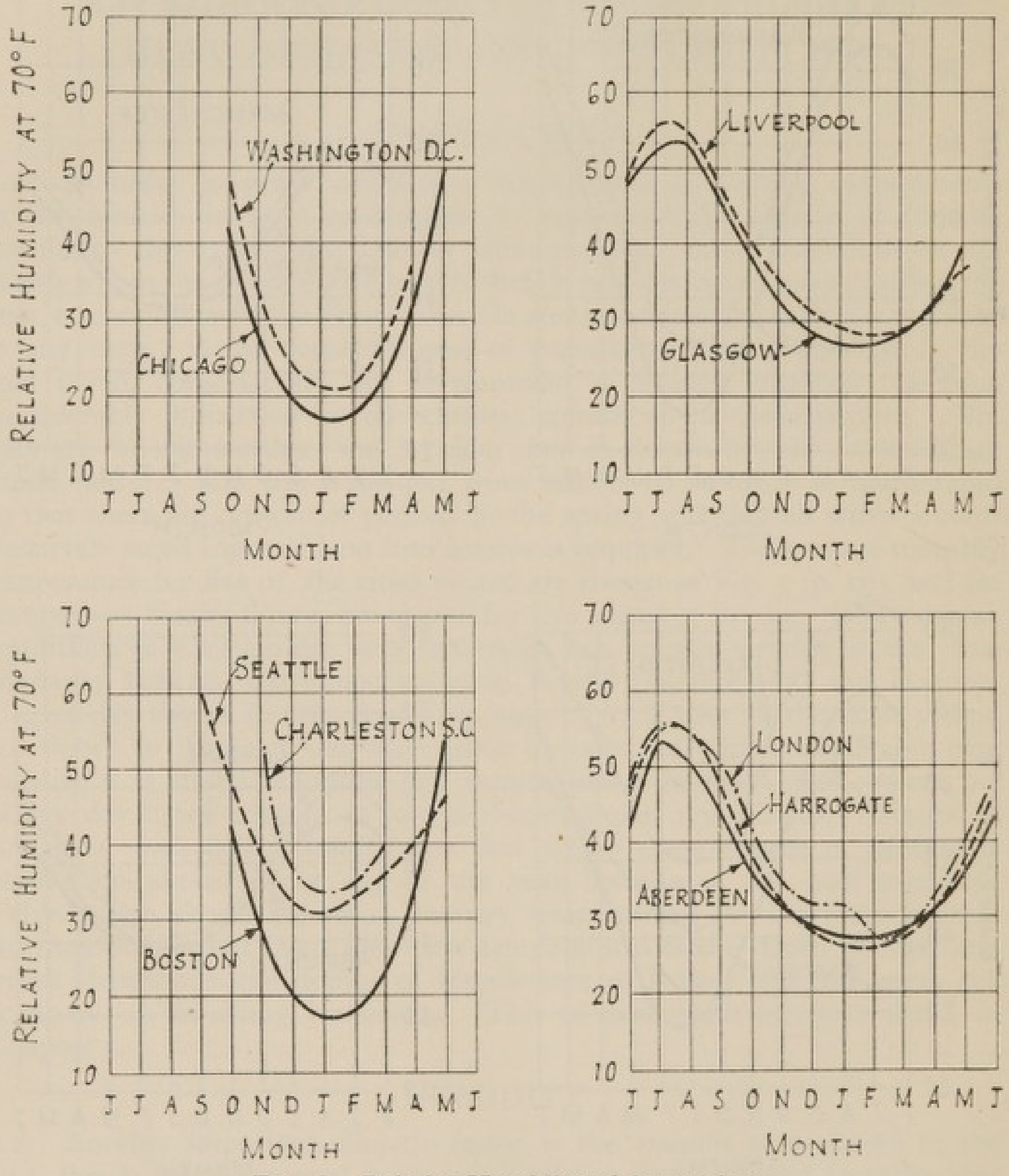


FIG. 6. Relative Humidity of Atmosphere adjusted to 70° F. for five U.S.A. and five British Cities.

humidities as are experienced throughout the year and from place to place in the States has led to some study of the most desirable value of humidity for human comfort. It is considered that at a temperature of 70°F. human beings are most comfortable when the relative humidity is somewhere between 30 and 60 per cent. but the range has not been determined with accuracy. Above this value there is a sense of dampness whilst below it there is a feeling of dryness. There are other factors which can produce a sensation of dryness and recent researches on this are referred to in Chapter 13. The low amount of moisture in the air appears to have a

TABLE 3

Degree Day Figures and January Temperatures for American Cities Visited

Cities	Degree Day 65°F. Basis	Mean January Temperature
Boston	5,943	28·5°F.
Charleston S.C.	1,870	50·4
Chicago	6,287	22·3
Cleveland	6,171	26·5
Columbus, Ohio	5,536	29·6
Detroit	6,580	24·9
New York	5,306	30·9
Pittsburgh	5,466	31·0
Portland, Oreg.	4,379	39·4
St. Louis	4,610	31·1
Seattle	4,864	40·3
Washington	4,598	33·4

TABLE 4

Sunshine, Annual and Winter for American Cities Visited and some British Cities

Cities	Hours of Sunshine per Year	Hours of Sunshine Nov.–Dec.–Jan.–Feb.
Boston	2,561	582
Charleston S.C.	2,941	797
Chicago	2,652	431
Cleveland	2,338	455
Columbus, Ohio	2,468	465
Detroit	2,324	414
New York	2,791	664
Pittsburgh	2,318	412
Portland, Oreg.	2,154	315
St. Louis	2,697	601
Seattle	2,067	298
Washington	2,576	718
London	1,460	206
York	1,241	163
Aberdeen	1,314	211
Glasgow	1,095	115
Manchester	966	66

considerable effect on comfort out-of-doors in cold weather, as we found that we felt no colder in the U.S.A. at a temperature 20°F. lower than in England where the humidity is greater. Similarly, Americans visiting England feel the cold out-of-doors even though the winter temperature may be appreciably higher than that to which they are accustomed.

SUNSHINE

2.3. Table 4 shows that sunshine figures for many districts are considerably higher than in this country.

TEMPERATURE REQUIREMENTS

2.4. The low temperatures prevalent in so many parts of the U.S.A. have several important effects on the heating arrangements in houses. In these parts it would be impossible to be comfortable without some heating throughout the house. Moreover the thermal shock would be considerable in moving between heated rooms and other parts of the house, which incidentally would be icebound for a considerable part of each winter.

2.5. The desired temperature in living rooms was usually said to be about 70°F. but generally the thermostat, where one was fitted, was set several degrees higher. We took air temperatures in most of the houses and offices visited and found that it was usually about 75°F. in houses and even higher in most offices and hotels. It was generally agreed by most Americans that the temperatures in offices and hotels are too high. It is regarded as being highly important that the whole of the house be heated, although there appeared to be a general desire for the bedroom temperature to be somewhat lower than the rest of the house. We had several discussions on the relative merits of heated and unheated bedrooms and American research workers are convinced that some warmth is desirable. It must be pointed out here that the temperature of an unheated bedroom in America may be as low as 0°F., whereas we think of a minimum temperature of about freezing point (32°F.). There is said to be evidence that sleeping in unheated rooms in a cold climate leads to a considerable increase in sinus troubles. Air is inhaled at a very low temperature and has to be heated in the nasal organs to body temperature before passing to the lungs. The excessive amount of heat which has to be produced, places too great a strain on these organs during sleep and sinus troubles may result. Also it was said that cold is a stimulant and is therefore undesirable during sleep, the essential of which is relaxation. However, personal reactions differ considerably in relation to bedroom temperature and whether bedrooms should be cool or warm must be left to individual choice. It was found that a number of people opened their bedroom windows at night.

2.6. Consequently a system of heating is required, especially in the colder States, in which the living room is heated to the desired temperature, usually a little above 70°F. and the rest of the house is heated to this or a slightly lower temperature.

2.7. U.S. research workers who are studying heating in relation to bodily comfort seem to hold the view that comfort is not dependent upon the ratio of heat given off by convection to that given off by radiation. It is, however, considered undesirable that there should be an excessive heat loss in any one direction as may be the case when a single high temperature source is used for heating. There seemed to be no desire on the part of the public for high temperature radiant heating.

VENTILATION REQUIREMENTS

2.8. In Chapter 1 we refer to the fact that considerable efforts are made to keep the house construction as air-tight as possible and that ventilators or air bricks are not provided, windows to living rooms are usually kept closed in winter but sometimes bedroom windows are opened. We have no definite figures for the rates of air change actually occurring in normal houses, but clearly with this type of construction and the methods of heating used it must be appreciably less than in this country. This practice received the support of modern research which is referred to in Chapter 13.

HEAT LOAD FOR SPACE HEATING

2.9. We have referred to climate, temperature requirements and ventilation. These, together with precise location, size and heat insulation of the structure will determine the actual space heating load for any particular case. As an indication of what this heat load might normally be expected to be we think that existing regulations for wartime housing probably give a reasonable guide. These restrict the total heat loss to not more than 60 B.T.U. per hour per sq. ft. of floor area with the interior temperature at 70°F. and the exterior at the design temperature for the locality.

COOKING REQUIREMENTS

2.10. Cooking requirements are substantially the same as in this country except for a demand for rather higher speed in service.

HOT WATER REQUIREMENTS

2.11. The provision of adequate hot water (in American houses) has long been taken for granted; in 1940 about 90 per cent. of the houses in urban areas were provided with water heating appliances as compared with about a third of the houses in England.

2.12. The amount of hot water which will be used by a family in any house is not amenable to calculation as it depends upon such variable factors as personal habits as well as running costs. We were fortunate, however, in being able to obtain a considerable amount of statistical data which had been collected in various parts of the States both in houses in which the occupants paid for the fuel used for heating the water and in houses in which the cost of fuel for water heating was included in the rent or where piped hot water was laid on in unlimited quantities for a fixed charge. These data are dealt with in some detail in Appendix 2. As would be expected, the consumption of hot water varies considerably in individual houses but the average figures obtained in various localities were very similar. In houses where the occupants paid for the fuel the consumption was about 33 Imperial gallons per day. This is rather less than the quantities which have recently been suggested in this country as being reasonable minimum requirements. Where the cost of hot water is included in the rent the statistics cover over 10,000 houses and the average consumption was 50 Imperial gallons per day. The fact that these latter hot water consumptions are so consistent in quantity is most impressive and is of extreme importance in connection with district or grouped heating schemes and the figures also indicate that people given an unlimited supply do not indulge in unreasonable waste.

2.13. The temperature of hot water supplies was usually from 140° to 160°F. and there was always a rapid flow at baths, sinks and wash basins. The provision of shower baths in addition to tubs was fairly common, particularly in the rather higher income group housing. In some wartime houses showers were installed as the only type of bath but this appeared to be a purely emergency measure and our impression is that a shower only would not be regarded as adequate. We found that estimates of water consumption by showers varied greatly and it seems that the reason for this is the variation in type of shower spray used. The quantity of water can be reduced to a very small amount with some types of shower head, but with other types may be at least as great as for a tub bath.

FUEL COSTS INCLUDED IN RENT

2.14. We visited a number of housing estates where unrestricted supplies of fuel or hot water were available. In some, electricity or gas for water heating or cooking or both was supplied unmetered to individual housing units, and the total cost divided either equally or in proportion to the rent. In other estates solid fuel and oil were provided to the tenants as they required them. When their supplies were running short they merely had to ask the estate manager to have them replenished. In some cases the rentals were adjusted periodically in accordance with changes in the aggregate fuel cost for the whole estate over the immediately preceding period. In other cases such adjustment was considered unnecessary.

2.15. It was agreed that fuel consumptions would be somewhat higher when this method was employed than when the tenant purchased his own fuel, but it was considered that the total cost would be no higher because of the favourable terms afforded by the gas and electricity undertakings and the solid fuel and oil merchants for supplying fuel in large quantities. In addition there is a considerable saving in not having to install and read individual meters and in accountancy and the collection of individual bills. [In some parts of the U.S.A. where individual electric meters are installed it is obligatory to have them outside the house so as to save time in meter reading.]

2.16. Conditions in America are such that whatever system of payment there may be for water heating or cooking, the whole house will be continuously heated to a fairly high degree so that possibilities of increased usage of fuel for space heating are much smaller than they would be under present conditions in Britain.

FUEL RESOURCES OF THE U.S.A.

2.17. The fuel resources of the United States are abundant, varied and widely distributed. In addition to bituminous coal, anthracite, oil and water power there is a large production of natural gas. The production of these various fuels for 1939 and the estimated quantities used for domestic purposes are shown in Table 5.

2.18. The retail prices of the various fuels on 15th October, 1944, in the cities which we visited are shown in Appendix 5.
The considerable variety in price of the different fuels is most striking and to a large extent determines the proportionate use of the various fuels for domestic purposes. The price differences are due chiefly to the distance of the cities from the source of the raw fuel, some of these distances may be very large. The method of transportation of the fuel also effects the price.

2.19. *Bituminous coal.*—The chief bituminous coalfields are in the Eastern States where most of the industrial activity of the U.S.A. is centred, but there are coalfields in very many other parts of the U.S.A., as far apart as the State of Washington in the West, and Virginia in the East. Although a map may indicate a wide distribution of coalfields, it is important to appreciate that, because of the vastness of the United States, many towns may still be many times further distant from a coalfield than could be the case with any British town. The distribution and marketing and price fixing of bituminous coal is most complex; this had been studied in considerable detail by Mr. R. N. Quirk of the Ministry of Fuel and Power, who visited the U.S.A. for this purpose before the war.

2.20. *Anthracite.*—Anthracite production, which is about 13 per cent. that of bituminous coal is confined almost entirely to the Pennsylvanian fields. The quality of American anthracite is in general inferior to that produced in South Wales; ash contents of 10 per cent. are common.

2.21. *Oil.*—Production is centred chiefly in the South, from where the oil is transported by pipeline, railroad and tanker to all parts of the States. Many oil-burning domestic heating plants are completely automatic and are serviced by the oil distributors so that the householder has to give them no attention whatever. In other cases the householder merely has to make sure that the oil supply tank is never allowed to become empty and to light the pilot jet at the beginning of the heating season, but even this is unnecessary if it has been left alight throughout the summer. We heard of no cases of oil being piped direct to houses.

TABLE 5

Total Production of Fuels in U.S.A., 1939, *compared with Consumption for Domestic Purposes*

Fuel	Total Production for all purposes including export	Estimate of Fuel consumed directly for Domestic Purposes		
		Quantity	Million Therms	Therms as a Percentage of Total Domestic Therms
Bituminous coal (tons) (2,000 lb. per ton) ..	396,000,000(1)	65,000,000(2)	17,500(3)	29·5
Anthracite (tons) (2,000 lb. per ton)	51,500,000(1)	30,000,000(1)	8,000(4)	13·5
Coke (tons) (2,000 lb. per per ton)	57,000,000(16)	8,000,000(17)	1,920(18)	3·0
Briquettes and package fuels for domestic use (tons) (2,000 lb. per ton)	1,000,000(1)	1,000,000(1)	240(18)	0·5
Wood	—	—	14,500(14)	24·5
Crude petroleum (barrels) (42 U.S.gals.per barrel)	1,265,000,000(1)	173,000,000(1)	10,700(5)	} 18·5
Natural gasoline (U.S. gals.)	2,200,000,000(1)	80,000,000(6)	100(7)	
Natural gas (million cu.ft.)	2,477,000(8)	374,000(9)	4,000(10)	7·0
Manufactured gas (including some natural gas)(11) (million cu. ft.) ..	387,000(11)	247,000(12)	1,500(13)	2·5
Hydro electricity (million kW. hr.)	43,400(15)	21,150	700	1·0
Other electricity (million kW. hr.)	83,800(15)			
TOTAL	—	—	59,160	100

1. Bureau of Mines Mineral Year Book.
2. Bureau of Mines Mineral Year Book gives between 55 and 77 millions.
3. Bureau of Mines Mineral Year Book: Thermal value taken as 13,000 B.Th.U. per lb.
4. Bureau of Mines Mineral Year Book: Thermal value taken as 13,600 B.Th.U. per lb.
5. Bureau of Mines Mineral Year Book: Thermal value taken as 6 million B.Th.U. per barrel.
6. Bureau of Mines Mineral Year Book: Domestic consumption as liquified gas only.
7. Bureau of Mines Mineral Year Book: Thermal value taken as 6 million B.Th.U. per barrel.
8. Bureau of Mines Mineral Year Book: Total production, of which nearly one-and-a-half million sold by Utilities.
9. American Gas Association: Figure excludes about 40 thousand million cu. ft. used for mixed gas.
10. Bureau of Mines Mineral Year Book: Calorific value taken as 1,075 B.Th.U. per cu. ft.
11. For details of build up *see* Appendix 5, Tables 17 and 18.
12. American Gas Association.
13. Taking calorific value as 600 B.Th.U. per cu. ft.
14. Estimate quoted by Mr. R. K. Thulman in paper read before the A.S.H.V.E.
15. The Edison Electricity Institute: Figures for all Utilities and government power production.
16. Bureau of Mines Mineral Year Book: Includes coke used for water gas production.
17. Bureau of Mines Mineral Year Book.
18. Calorific value taken as 12,000 B.Th.U. per lb.

2.22. *Natural gas.*—This is a sulphur free gas of high thermal value (about 1,000 B.Th.U. per cu. ft., *i.e.*, about twice that of manufactured gas). It is obtained from natural gas wells and also from oil wells. The main sources of natural gas are in the South and South-West and there are also supplies in Illinois, Ohio, New York, Pennsylvania and other States. The gas is piped under pressure from the wells to the points of consumption, which may be 1,000 miles away, where it is used in its original form, blended with coal gas or reformed. Table 5 gives details of the consumption of natural and manufactured gas. The average price of natural gas to the domestic consumer, on a thermal basis, is much less than that of manufactured gas. (Tables 18 and 23, pp. 120 and 122).

2.23. *Water power.*—The hydro-electric resources of the United States are considerable, and so far only a small proportion of them have been tapped. Of the total electricity production in the United States about 33 per cent. is derived from water power (Table 19, p. 121), but this is likely to be considerably increased if the projects now being considered for building further dams materialise. The use of electricity, for house heating, is most complex in relation to daily load variations, but there is an added complication in the case of hydro-electricity as the seasonal peak of electricity demand does not coincide with the peak of water availability. On the North-West coast the Bonneville Power Authority anticipate a considerable surplus of generating capacity when certain wartime aluminium plants close down and they are looking towards the domestic load as a partial solution of their problem. They are making a study of house heating requirements with special reference to smoothing out the demand and to determining what economic methods can be employed for off-peak supply to small houses and what proportion of houses should be so supplied in order to reduce the daily peak load. It should be noted here that the Ontario Hydro-Electric Commission are strongly opposed to the use of electricity for house heating as it would have far reaching effects on their whole system of water flow control and distribution—and this in a country where half the coal used is imported and about 98 per cent. of the electricity produced is generated by water power.

2.24. The price of electricity in the U.S.A. is generally much too high in relation to other fuels for its use for space heating to be considered, and even its use for cooking is very restricted. In the North-Western States where it is produced by water power and where oil and natural gas fields are remote it is relatively cheap, as will be seen from the prices for Portland or Seattle, in Table 23, p. 122. There is a much higher proportion of electric cookers in Portland or Seattle than in any of the other cities visited.

2.25. *Briquettes and packaged fuels.*—Nearly a million tons of briquettes and packed fuels are produced annually in the U.S.A. These fuels are made chiefly from bituminous coal, low volatile and anthracite fines. When bituminous coal is used in their production they are sometimes partially carbonised to reduce the volatile matter and so make them smokeless. The packaged fuels are wrapped tightly in heavy paper and sold locally. Such fuels appear to have a number of advantages, for example they aid in reduction of atmospheric pollution and may provide a useful and economic outlet for low grade material. Attention might well be given to the possibility of development for their production and usage in this country.

2.26. In St. Louis the smoke ordinances forbid, with certain exceptions, the use in hand-fired appliances of fuels with a volatile content exceeding 23 per cent., and we understand that as a result a number of manufactured fuel plants have been set up in the locality to produce a fuel conforming with the required standards.

2.27. *Wood.*—In certain areas the use of wood as a fuel is extensive, but reliable figures are obviously difficult to obtain. Also in some cases, especially in wood-producing districts, wood waste, including sawdust, is used for domestic water heating and for generating electricity.

2.28. *Solar heat.*—Heat from the sun is widely used for heating water for domestic purposes in Florida and neighbouring States and the use of solar heat for complete or partial house heating by hot water is being investigated. In addition a careful study is being made of the positioning and design of windows so as to take the fullest advantage of the heat produced by the sun. The value of such solar heating could be considerable and solar water heating would be of especial use in various parts of the British Commonwealth and Colonies as a means of obtaining adequate hot water supplies without the need for importing coal.

Chapter 3

THE RELATIONSHIP OF HEATING TO HOUSE PLANNING

GENERAL

3.1. In the recent British Housing Manual* the relationship of heating and house planning is emphasised. The usual house plan in the United States is very different from the normal pre-war plan in England and the relationship of plan and heating is very close indeed. This relationship is so important that it should be considered in post-war housing in this country because if the trend towards heating the entire house develops as it seems to be doing it is essential that the planning implications should be foreseen and parallel developments made. For this reason we describe here our impression of what has happened in the United States although in making generalisations we fully realise that our statements could be contradicted in detail from examples of other types of housing in certain localities. We believe, however, that as a broad picture our statement is correct.

OPEN PLANS IN RELATION TO WARM AIR HEATING

3.2. It appears that some 50 years or more ago, the average small house in U.S.A. was not very different from the English house. It consisted of a number of small rooms, each self-contained and heated either by some type of fireplace or by a closed stove ; at this stage each room would have a door. Our surmise is that since, because of the climate, the house was of necessity heated at least to some degree throughout the main rooms and hall that it was found unnecessary to keep the doors to individual rooms closed.

3.3. Having found that by habit the doors of living rooms were not often closed people began to omit some of the doors, possibly for economy or possibly for convenience. As a result there developed a type of plan in which the main rooms were connected to each other or to a staircase hall by an arched doorway, often about 5 ft. wide. This doorway sometimes had doors fixed in it but more often was retained simply as a feature but without any means of closure other than possibly a curtain.

3.4. With the development of heating from one central source of heat in the form of a space heater or with the simplest type of gravity warm air furnace having only one main return duct, the open plan became essential. It might be argued that the open plan developed and thus made possible this type of heating, but we believe that in fact the heating method was developed first and the open type of house plan was one of the consequences.

3.5. With forced warm air heating the need for open planning is not so great but in general it seems to persist.

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* *Housing Manual* 1944, H.M. Stationery Office, price 2/-

3.6. This open plan was particularly noticeable in some of the war housing where the plans were of two general types. In the first, the houses were small detached bungalows with a front door entering directly into a living room All other rooms opened off this living room. As a rule there would not be a door to the kitchen space. There would be doors to bedrooms and these doors would nearly always be left open in daytime. Occasionally there were grilles from living rooms to bedrooms to allow circulation of warm air when bedroom doors were closed.

3.7. In the case of two-storey houses the plan would usually consist of a front door again leading direct into the living room with kitchen space opening from this. The upper floor arrangement would be similar to our own but the stairs would usually lead up directly from the living room and not from a staircase hall. Warm air would circulate directly up the stairway and thus to bedrooms.

RESTRICTION OF PLAN SHAPE DUE TO METHOD OF HEATING

3.8. The use of any form of gravity warm air heating also has a direct effect on the shape of the house plan since for effective heating with space heaters or gravity warm air furnaces and for economy, and to some extent for effectiveness of forced warm air circulation, all rooms must be reasonably near the heater. In consequence it is found that the heater is placed fairly centrally in the plan and that the plan is usually of a compact type when this kind of heating is used. This is not usually of any great importance with the very small houses of the war housing type. It is clear that in parts of the country where much less heating is required that the plan shape does in fact alter quite appreciably. In the rather larger houses situated in cold regions the introduction of warm water radiator heating may have resulted in a more spread out plan being used in some districts because circulation was easier with water than with warm air.

ADVANTAGES AND DISADVANTAGES OF THE OPEN PLAN

3.9. Several points about this open type of plan occurred to us. We have referred elsewhere to the fact that in the colder regions considerable attention is given to making the houses as resistant as possible to air infiltration with the result that the rate of air change within the house is considerably less than is considered good practice in Britain. In spite of this small air change we were constantly impressed by the fact that the houses did not appear to be stuffy, even when too warm for our comfort. (There is in fact a good deal of confusion between " overheating " and " stuffiness ".) Probably the open type of plan which gives a much larger volume of air in one compartment may be the reason for this freshness of the air.

3.10. We were unable to find any evidence that there was any objection, either from the public or from health authorities, to this low rate of air change. In view of the very considerable amount of attention which is given to health and hygiene in many other ways, this acceptance of low air change is very significant.

3.11. Although this low rate of air change will be of the greatest importance economically with warm air methods of heating it is obviously a very real factor in the running cost of other types of heating also. The whole subject of ventilation requirements needs to be further studied, taking into account the factors mentioned above.

3.12. It seemed curious to us that in view of the care taken to draughtproof the houses the external front door usually opened directly into the living room of low income housing.

3.13. The arrangement of stairway opening direct from the living room should give the planner more latitude in the placing of the stairs, but we did not find that any special advantage had been taken of this.

3.14. It may be thought that the open type plan and the use of air circulation by ducts would lead to objections on the ground of noise nuisance and lack of privacy. This did not seem to be the case. To some extent this may be due to the different attitude and methods of living. The American seems to be much less shy of doing things publicly, and therefore, presumably does not require that his own house should be divided into a series of sealed compartments. It also seems to be true that a general background of noise does not disturb him. We found repeated instances of evidence on this point, even to the extent of being told by a number of people that they could work better with a background of noise.

3.15. There is, of course, an additional reason why the open type plan may have been preferred in the wartime houses, and that is because they are so very small in size that they would appear impossibly cramped unless kept fairly open in plan. This, however, would not account for the very general acceptance of the open plan in larger houses and in apartments for the rather higher income groups where it is almost always adopted.

3.16. In connection with this very general acceptance of the open type plan in America it occurs to us that there are already indications of some movement in this direction in our own house plans. To some extent it can already be seen in some recent small house designs and in pre-war plans of more costly houses with some degree of central heating there was certainly a tendency in this direction.

THE USE OF BASEMENTS

3.17. The basement is a traditional feature in many parts of America and is still strongly demanded in the colder regions. Table 6 shows the results of a nation wide survey on the incidence of basements and also of single-storey, one-and-a-half storey and two-storey houses. It can be seen from this that about half the single-storey houses and by far the majority of other houses have basements.

3.18. We believe that this demand is sufficiently important to warrant some consideration of the usefulness and cost of basements. We therefore describe in some detail the situation as it appears to be in America.

3.19. First, what is the purpose of the American basement ? Undoubtedly its prime function is to house the heating plant and fuel supply. It is also used as the place where clothes washing and often clothes drying, is done.

TABLE 6

Proportion of Basement and Non-Basement Detached Houses

	With Basement	Without Basement	Total
Single-storey houses ..	35·5 per cent.	38·5 per cent.	74 per cent.
1½ Storey	10·5 per cent.	1·0 per cent.	11·5 per cent.
2 Storey	13·0 per cent.	1·5 per cent.	14·5 per cent.
All houses	59·0 per cent.	41·0 per cent.	100 per cent.

Note.—Most terrace houses and multifloor houses have basements.

It is used for general storage and frequently as a children's play space and as a workshop. Taking these points in order the following comments are made.

3.20. As has been mentioned in the description of gravity warm air furnaces this type of heating requires the furnace to be in a basement in order to obtain a sufficient rise to the air inlets to ground floor rooms. The basement permits easy handling of horizontal lengths of air ducts. It might be argued from this that a disadvantage of this type of heating is that it must of necessity be placed in a basement. While this is true there are other factors to take into account. Even where a forced warm air system is used it will be put into a basement whenever possible, in particular if it is a solid fuel fired heater. The very strong objection to having the dirt caused by the firing and ash removal of a solid fuel heater in the living room is one of the commonest arguments put forward for basements. The use of the basement for fuel storage is also considered an advantage. A very real asset of the heater in the basement is the resultant warmth obtained under the entire ground floor.

3.21. As a place for clothes washing the basement is apparently found convenient. It is frequently used for subsequent clothes drying for which purpose the heat from the furnace is useful. It may be noted here that the extremely cold winter climate in some districts makes indoor clothes drying more or less essential for a considerable part of the year. Presumably a separate working room at ground floor level would be even more convenient but we found little evidence of the provision of such a special room in small houses, the usual alternative to the basement being to do the washing in the kitchen. Apparently most housewives preferred the basement to the kitchen.

3.22. For general storage purposes the basement was definitely useful, but too often it appeared also to be a convenient place to dump a great deal of useless material. Again, however, we found that where there was no basement it was unusual to find any adequate alternative accommodation.

3.23. The use of a basement for workshop or children's play space in bad weather may not be an ideal arrangement, but it was certainly appreciated by many people. Again no alternative was provided in non-basement houses.

3.24. From the above description it can be seen that there is a demand for accommodation not unlike our own requirements but that in America the demand is either met by the provision of a basement or not at all, but where a basement is provided the space available is considerably more than is likely to be provided by alternative accommodation in post-war houses in this country. It is very important to note that we met no case of basements being used as normal habitable rooms in the way that the old-fashioned basement in this country was used.

3.25. If one enquires the reason for providing accommodation in a basement rather than as additional area at ground level, one is often told that the basement accommodation is cheaper. There is one climatic reason for this, namely, that foundations frequently have to be taken to at least 4 ft. below ground because of the frost penetration and that, therefore, the additional cost of excavating the entire site for a basement is not very great. Clearly there is a difference here from English conditions. It must also be noted that, because of frost, sewers are well below ground whereas in England we would need to consider the effect of basements on drainage costs. Also it may be that it is more difficult or costly to waterproof a basement against our conditions than American. On the other hand the recent rapid development in the use of mechanical diggers is so marked that it may well alter the whole economic aspect of constructing basements in this country as well as in America. In U.S.A. it is now quite common to hire a digger by the hour or day to excavate the basement of a single house on an isolated site in the country. We consider that in view of this change in available technique and of other possible advantages that the whole question of basement accommodation for houses in this country should be reviewed as a new possibility.

SITE PLANNING FOR SHELTER

3.26. A study of the well recognised figures on heat insulation value of walls shows the difference between " exposed " and " sheltered " conditions. The use of trees on exposed sites to provide a degree of shelter is appreciated by some architects in the colder regions.

SUMMARY

3.27. There is certainly a very close relationship between house planning and methods of heating, and this relationship should be fully noted and advantage taken of it in future developments in this country. There is some risk of development in either heating or house plan going ahead without the essential corresponding parallel changes being recognised. It is likely that if some method of heating the entire house is adopted that it will eventually lead to changes in plan type and we suggest that experimental houses of various types of plan might be built with a view to finding in advance the reactions of British families so that full advantage of the more efficient methods of using fuel may be taken and combined with the most suitable types of plan for our requirements. The economics of basement construction by modern methods should be investigated and trials with such basements and American types of heating should be included in experimental houses. Ventilation requirements should also be given further consideration, particularly in relation to the effect of the open type of house plan and to the methods of heating by warm air circulation.

Chapter 4

DISTRIBUTION, SALES AND MAINTENANCE OF APPLIANCES

(Including relative importance of fuels and heating methods)

DISTRIBUTION

4.1. Before discussing selling methods it may be helpful to give here a general quantitative picture of the relative importance of the different fuels used for cooking and house heating.

4.2. Figures in Table 7 which are taken from a recent official survey show the number of houses using different fuels for cooking as a percentage of the total number of occupied dwellings (37 million). Separate figures are given for the urban areas (nearly 22 million) and for the rural areas (15 million) so that it is possible to see the importance of, for example, wood in rural areas.

TABLE 7

Different Fuels Used for Cooking as a Percentage of Occupied Dwellings

Fuel	Urban areas only	Rural areas only	Total Rural and Urban areas
Coal or Coke	8	16	11
Wood	6	49	24
Gas	73	14	49
Electricity	5	6	5
Kerosene or Gasoline	7	14	10
Other or none	1	1	1
	100	100	100

It is particularly interesting to compare gas cooking with electricity. The overall figure for the U.K. has been estimated as 66 per cent. gas and 10 per cent. electricity. The extent to which houses in this country have solid fuel appliances as well as gas or electricity is not known, but it must be above three-quarters and up to 1939 duplicate services were still being installed, whereas in the States duplication is negligible. It is unfortunate that we have not sufficient statistical data in this country to make a complete comparison and elsewhere in this report the need for adequate statistics is urged.

4.3. Table 8 gives an indication of the relative importance of the different methods of house heating used throughout the country. It will be seen that the use of the fireplace as a means of heating is small but the stove is very common, particularly in rural areas.

TABLE 8

Different Methods of House Heating as a Percentage of Occupied Dwellings

Method	Urban areas only	Rural areas only	Total Rural and Urban areas
Steam or hot water	33	6	22
Warm air	25	13	20
Stove	35	63	47
Other, including fireplace as sole means of heat	7	18	11
	100	100	100

Note.—A survey in 1940 showed that the proportion of ducted warm air systems in *new* houses was about 20 per cent. gravity warm air and 20 per cent. forced warm air with a reduction to 40 per cent. for space heaters and " other " methods. Even so, these figures probably do not reflect the true proportions in new houses likely to be built as the 40 per cent. for space heaters is almost certainly higher due to war conditions than it would otherwise be.

4.4. The two tables following show the relative importance of the various fuels used in the two main systems of heating: (1) piped or ducted from a central source and (2) by stove or non-piped method. The figures show how wood is used more in the ordinary stove or space heater. This is not so much because wood is more suitable for this purpose but because the stove is used more in rural areas. This is shown clearly in the second table which gives the relative importance of the different fuels for all types of heating together and divided to show the difference between rural and urban areas. Similar details split for individual towns visited are given in Table 23 (p. 121).

TABLE 9

Different Fuels Used in the Two Main Methods of Heating

Method	Fuel	Urban areas only	Rural areas only	Total all areas
Steam, water or warm air piped or ducted . .	Coal and coke . .	78	75	77
	Wood	1	10	3
	Gas	9	5	8
	Oil	12	10	12
		100	100	100
Stoves and other non-piped or ducted method	Coal and coke . .	47	34	39
	Wood	13	56	38
	Gas	26	5	14
	Oil	14	5	9
		100	100	100

TABLE 10

Different Fuels Used for House Heating as a Percentage of Occupied Dwellings

Fuel	Urban areas only	Rural areas only	Total Rural and Urban areas
Coal and coke	65	41	56
Wood	6	48	23
Gas*	16	5	11
Oil..	13	6	10
	100	100	100

* A large proportion of this is Natural Gas.

4.5. From the above tables it will be seen that coal and coke are by far the most important fuel used for house heating. The proportion of coke is small, less than 4 per cent. of total solid fuel. Anthracite is included under the heading " Coal and Coke ".

METHODS OF SELLING

4.6. Selling methods in the United States and Canada are different from those in Britain. The differences are not only conditioned by the size of the country, where freight charges limit national distribution of appliances, but different channels for the sale of the appliances are used.

4.7. It is estimated that in the United States less than one-third of the gas appliances are sold through the American supply undertakings. Over two-thirds are sold through retail stores, dealers and other agents. This general pattern applies to the sale of electric appliances as well. The normal retail department store will often have a department selling all types of domestic appliances including solid fuel.

4.8. A typical method of selling is through such businesses as Sears Roebuck. This particular firm has a nation-wide mail-order business and also operates a chain of stores in most large cities. It is estimated that more gas appliances are sold through these stores than through any other single channel. They sell all types of domestic appliances complete with instructions for the purchaser to install himself and they even go to the extent of hiring out sets of tools needed for installing the appliances. In their head offices at Chicago they also maintain a large and efficient testing laboratory which is described further in Chapter 13.

4.9. These various distribution channels including the Utilities compete on fairly equal terms and the margins available are similar for each method. In the time at our disposal, we were unable to make a full and exhaustive study and we have no statistical information on margins, life and turnover of appliances and the degree of regional or national distribution, but these basic differences referred to above are important and may to a considerable extent account for differences in design referred to later.

SALES *versus* HIRE

4.10. During our visit we did not come across, or hear of, any cases where domestic fuel-burning appliances were available on hire, direct sales being the common method. Hire purchase terms are readily available, the duration of the purchase usually being up to three years with a rare maximum of five.

INFLUENCES OF DIRECT SALE ON DESIGN

4.11. Selling direct to the customer through competitive channels and selling without the option of hire, probably has had an effect on the design of the appliances. In Britain where the distribution of appliances is concentrated through the supply undertakings and where there is a considerable volume of hire business, it is important for the supply undertakings to encourage manufacturers to design long-lasting, trouble-free appliances. In the United States, on the other hand, there is no such strong and concentrated influence and as the manufacturer is able to sell through whatever sales channels he likes, he is all the time striving for new business and this probably accounts for the greater degree of " stylising " and less robust manufacture.

EDUCATION OF LOCAL AUTHORITIES

4.12. Responsibility of the Federal or State Authority for housing the low income groups of the population is a recent development and the machinery set up to deal with this problem is described in Chapter 1. At that time there was no experience of community housing and one of the first jobs undertaken by the United States Housing Authority was to give education, advice and instruction to the local authorities throughout the States. Much of this advice was distributed in a series of bulletins, some of which dealt with the heat installation. These bulletins gave advice on how to estimate fuel running costs and how to select the most suitable installation for each particular purpose. The kind of advice issued would be comparable with that given by the Ministry of Health to local authorities in England, and with the growing importance of heating problems in this country we believe that publications of a somewhat similar kind would be most valuable. The advice should cover, for instance, how to balance first cost with running cost and should include objective advice on the relative merits of the different fuels when used for each purpose.

4.13. In the United States, the Central Housing Authorities are very much aware of the importance of balancing running costs with first cost. This has been impressed upon them, particularly in those cases where fuel is supplied to householders in unlimited quantities and its cost included in the rent in the same way that hot water is supplied in unlimited quantities to apartments for tenants in the higher income groups of the population. The officials we talked with would have welcomed some legislative device authorising housing authorities to pay a higher price for a more efficient installation if it could be shown that the extra cost would be covered within a reasonably short period and so enable them to act in the same way in this matter as a business concern would. At present there are no such powers and tight Congressional Regulation fixing a maximum cost of houses tends to have the reverse influence. We believe that an attempt should be made to solve the problem in Britain. We have, for example, the wartime regulations sanctioning under certain conditions the purchase of higher-priced industrial fuel-burning equipment if it can be shown that the estimated value of savings over four years is more than the extra cost of the installation and we believe that such administrative devices should be extended to local authorities in connection with the housing programmes.

PURCHASE BY LOCAL AUTHORITIES

4.14. Federal and local authorities sometimes purchase appliances direct from manufacturers. This does not have the same upsetting effect in America as it would probably have in this country, since there is no one recognised channel for the sale and distribution of appliances.

4.15. In Canada special legislation has been passed recently to enable the Federal Government to place bulk orders for appliances. One of the reasons for this was the desire to make it possible for manufacturers to produce new models on a large scale with an assurance of a sufficient market.

STANDARDS

4.16. The co-ordination of standards, such as is carried out by the British Standards Institution in this country, is less developed in America than in Britain. On the other hand the gas industry, through the American Gas Association, has gone a considerable way to establish performance standards and in the majority of cities it is now illegal to sell, install, or use gas appliances which have not been approved by the A.G.A. and, at the request of the Utilities, supplies of unsatisfactory equipment may be stopped. The electrical industry has not developed so far in this direction, but in most Canadian provinces it is illegal to sell electric appliances which do not conform to the safety requirements of the Canadian Standards Association.

MAINTENANCE

4.17. As we have said above, more than two-thirds of the domestic gas appliances are sold and installed by retail stores, dealers and plumbers and less than a third through the Utilities. Most of these appliances carry with them a form of guarantee lasting one or two years or the duration of the hire purchase. During this time maintenance is usually undertaken by the seller of the appliance. At the end of the guaranteed period there is a tendency for maintenance to be carried out by the Utility but this is by no means universal practice and only in a few cases do the Utilities welcome the job and seldom did we find any appreciation by the Utilities of the importance of maintenance as an aid to sales. It is interesting to note that, in conversation with a big utility company in the Eastern States, we were told that they had no maintenance staff of their own and were endeavouring to give training to local plumbers to carry out this work for them. In Britain a housewife would automatically call for maintenance service from her local supply undertaking, whereas the American housewife would just as likely call the local dealer or distributor. On the whole we were told that the Utility Service would tend to be better and usually less costly than other means. During our conversations with housewives we never had any impression that servicing and maintenance was unsatisfactory.

Chapter 5

SMOKE ABATEMENT

GENERAL

5.1. The striking thing about smoke abatement in the United States was the degree of awareness of the problem and the very considerable interest being shown in the subject by a variety of people in many different towns.

5.2. We visited St. Louis, a city of 850,000 inhabitants, where the problem has been attacked in a vigorous fashion and where the results in terms of smoke reduction are extremely satisfactory. It appears to be agreed by common consent that St. Louis was one of the dirtiest cities in the country, but now it is quite remarkably smoke-free. The present smoke laws in St. Louis which came into operation in April, 1940, are described below.

REGULATIONS IN FORCE IN ST. LOUIS

5.3. The essential points in the regulations are :—

(*a*) Bituminous coal of more than 23 per cent. volatile matter may be used only in appliances fitted with automatic stokers ; and if of a size which will pass a 2-in. circular mesh it must be cleaned if it contains more than 12 per cent. ash or 2 per cent. sulphur on a dry basis.

(*b*) Solid fuel which has been treated by certain processes may be used even if it contains more than 23 per cent. volatile matter provided it is approved as being a " smokeless " fuel.

(*c*) All fuel dealers must be registered and renew permits annually.

(*d*) All new appliances installed and all alterations to existing appliances must be notified to and approved by the Smoke Commissioner.

(*e*) The city is given power, in an emergency, to purchase and arrange distribution of fuel.

5.4. Prior to the passing of the regulations there had been widespread complaint among citizens generally and by the medical profession. In the progress towards the framing of regulations there were full consultations with a Citizens Committee. The final regulations were the result of recommendations of a Special Committee of the City Council which reported in February, 1940. This Committee considered various alternatives including the following :—

(*a*) *An Educational approach instead of Regulations.*—This was considered unlikely to give satisfactory results.

(*b*) *A Subsidy on smokeless fuel to enable it to be purchased at similar prices to the fuel in use.*—This was rejected on various grounds. The existing fuel prices in St. Louis were much lower than in many other large cities, therefore it was considered unnecessary to subsidise. There was the danger of a subsidy being abused by constant demands for higher subsidies. Furthermore it could not be applied only to those in need of it but would have to be given to rich and poor alike. Finally, although the smokeless fuel would cost more per ton it would not cost a great deal more per therm.

(*c*) *The use of Natural Gas in place of bituminous coal.*—This was rejected on the grounds that it would require large conversion of existing appliances and that there would be a much higher load on gas mains, which could not be accommodated without very serious capital expenditure and the mains thus provided would not be functioning economically because of the serious peak load conditions. Moreover, it would be necessary in a climate such as that at St. Louis to provide artificial gas plants as an emergency supply in case of interruption of the natural gas supply.

(*d*) *The use of District Heating.*—While this was considered practicable for certain areas it was not considered economically possible in much of the less densely populated districts.

(*e*) *The provision of a Municipally-owned gas or coke plant.*—There were a number of technical difficulties to this but the chief objections appeared to be that it was considered inadvisable to place all the fuel resources of a city of the size of St. Louis upon one supply and one character of fuel, and it was felt that a municipal plant would stifle development by private enterprise of various types of smokeless fuel.

5.5. The Committee therefore recommended the measures given above in paragraph 5.3 and also included in its recommendations advice that the Division of Smoke Regulation be enlarged to meet the increased demands which would be made on it.

THE FUNCTIONING OF THE REGULATIONS

5.6. The Committee reported in February, 1940, and the new Ordinance came into force in April, 1940. There was an immediate problem of providing an adequate supply of smokeless fuel for the next heating season. This appears to have been done with complete success.

5.7. The present staff of the Smoke Commissioner consists of 22 employees, including 14 inspectors. All conversions of plant, new plant installations or alterations to existing plant are approved by this staff and in addition the inspectors investigate any complaints which are lodged and also watch for cases of infringement. Smoke emission is limited under the regulations and measurements are based on the Ringlemann Chart method, smoke being considered dense when it is equal to or greater than No. 2 of the chart. The Smoke Commissioner always endeavours to obtain the desired results by persuasion. If a case of smoke emission is reported the person responsible is invited to the Commissioner's office to discuss ways and means of overcoming the difficulty. In the first four years of operation under the Regulations there were 229 cases involving illegal fuel. The majority were for illegal sale. In nearly every case involving conviction of a licensed dealer, his permit was revoked. In cases of smoke emission the method of persuasion has been remarkably successful and only 166 violations have been taken as far as the police courts. Apparently the only serious objection to the regulations comes from the lowest income groups who find the increased cost of fuel something of a hardship.

5.8. The Regulations have functioned satisfactorily under both Republican and Democratic power and in 1942 the right of the City to make and enforce such Regulations was upheld by the Supreme Court of the State of Missouri.

EFFECT OF REGULATIONS ON FUEL AND APPLIANCES

5.9. As would be expected, there was objection to the scheme from the owners of the nearby bituminous coal mines. This appears to have been over-ruled. One result of the cessation of usage of this coal in many of the smallest houses is that coal peddlers, who operated on a small scale carrying coal direct from mine to householder, have been put out of business.

5.10. The production of processed fuels has increased rapidly under private enterprise. Various types are in production, including briquettes. Some of these are made from the dust from dry coal-cleaning plants. This dust contains a high percentage of fusain and although it may have as much as 35 per cent. volatile matter it is relatively smokeless and has been approved for use. The Administration issues a list of coal mines and of manufactured fuels which are suitable for use in hand-fired appliances and the merchants have to state on their delivery note the reference number of the mine or fuel.

5.11 There has been a considerable conversion to mechanical installations since the passing of the Regulations in 1940. Table 11 shows the number of permits which were issued in the years 1939–42.

TABLE 11

Number of Permits Issued

		Stokers	Oil Burners	Gas Burners
1938–39	..	1,417	231	450
1939–40	..	1,950	243	744
1940–41	..	5,986	374	940
1941–42	..	5,454	368	910

SMOKE REDUCTION EFFECTED BY THE REGULATIONS

5.12. It is most unfortunate that soot fall measurements, before and after the operation of the smoke laws, are not available. Soot falls in St. Louis in 1927 averaged 778 tons per square mile (records taken in January) with figures for different districts, all within the city, varying from 159 to 4,660 tons per square mile. The deposition of ash alone in industrial towns of Britain may be as much as 2,000 tons per square mile per year in particular districts and the total deposition is even greater.

5.13. The United States Weather Bureau records smoke daily as " moderate " or " thick ". Table 12 gives a summary of these observations for the last heating season preceding the passing of the smoke regulations and for the two succeeding seasons.

TABLE 12

U.S. Weather Bureau Recordings of Smoke in St. Louis

	Moderate Smoke			Thick Smoke			Total Smoke		
	Days	Hours	Reduction per cent.	Days	Hours	Reduction per cent.	Days	Hours	Reduction per cent.
1939–40	70	599	—	37	117	—	82	716	—
1940–41	44	178	70·3	9	19	83·6	46	197	72·5
1941–42	47	157	73·6	12	26	77·7	47	184	74·3

5.14. Records of the Division of Smoke Regulation show that: "Smoke emitted by all industrial stacks in St. Louis has decreased from an average of 0·25 units per observation in 1941 to 0·11 in June, 1944. (These records were not kept before October, 1941.)

5.15. In addition to attacking smoke from buildings there has also been an attempt to reduce smoke from railway engines. Apparently this has succeeded to a considerable extent because it is stated that "Locomotive smoke has decreased from an average of 1·73 units per observation in 1939 to 0·85 units in June, 1944". Moreover, 100 Diesel locomotives have been put into service as a result of this drive.

5.16. While it is unfortunate that more precise evidence is not available on the actual smoke reduction achieved there is no doubt whatever that it has been very striking indeed and officials of other towns are quite jealous of the results obtained by St. Louis. We discussed its effect on cleaning and other matters and were told that shopkeepers were aware of a considerable reduction in "shelf losses". Dry cleaners apparently did not suffer a loss of business, the explanation being that it was now considered worth while having things cleaned because they remained in reasonable condition for some time. The manager of a large hotel thought that it must have resulted in a saving on cleaning of fabrics of at least 30 per cent.

5.17. Before the introduction of the Regulations it was believed that about 70 per cent. of the smoke came from domestic and commercial premises. In walking through the city the absence of smoke from domestic chimneys was most striking.

SUMMARY

5.18. We were able to examine in some detail the smoke laws in force in St. Louis. It is clear that the very drastic regulations have resulted in a most marked improvement. This has been done by forbidding the use of high volatile coal except in mechanically operated appliances. Effects of this have been, first an increase in the production of smokeless fuels and second, an increase in mechanical stokers and to some extent in gas and oil fired plant.

5.19. The regulations employed by St. Louis clearly could not be suddenly enforced on a number of towns in one area without serious consequences to the mining industry. It seems unlikely, therefore, that the solution found here can be applied on a wide scale. However, the fact that St. Louis, previously one of the worst cases of smoke pollution, has been able to tackle the problem successfully, has made other cities much more conscious of their responsibilities. There are many evidences of awakened interest including the design of appliances to burn coal smokelessly. We mention in Chapter 13 two of these which we saw, the Fellowes furnace at Urbana and a smokeless heater at the Batelle Memorial Institute at Columbus.

Chapter 6

GENERAL PICTURE OF HEATING IN CANADA

GENERAL

6.1. In the very brief time which we spent in Canada it was only possible to obtain very general impressions. We found that, broadly, the systems of heating in use were very similar to those in U.S.A. The following brief notes mention certain features which seemed to us to be of special interest.

6.2. The organisation of housing in Canada is comparable with the F.H.A. in the United States, but there is no Federal department dealing directly with housing the lowest income groups of the population. These groups rely on the supply of old houses becoming vacant as the higher income groups move into new houses. To stimulate the building of the new houses the central authority assists by means of loans at low rates of interest. This speculative housing is done for the most part as fairly small operations each involving only a small number of houses. We were told that the largest operations would be unlikely to exceed 500 houses per year.

6.3. A recent interesting development was the passing through the Federal Parliament of a Bill which includes a clause to enable the central authority to purchase housing equipment in bulk. It was emphasised that bulk purchase would be particularly useful in stimulating and developing the manufacture and use of high efficiency fuel-burning appliances.

CLIMATE

6.4. From the heating point of view the climate of Canada is comparable with much of the U.S. Intensity of cold is of course greater, but otherwise it is similar to the Northern and Central areas. Vancouver and Victoria on the Pacific coast have a similar climate to Seattle and Portland and are comparable with England.

FUEL RESOURCES

6.5. The fuel resources of Canada are very different from those of the U.S. There is some natural gas in Western Canada and some coal in various regions, mostly rather poor quality. Over half the coal consumed is imported, mainly from the U.S. but some from Britain and Russia. Some oil is used and this is imported from the U.S. In timber areas sawdust stoves are common. A most noticeable difference is that over 90 per cent. of the electricity production is from water power.

HOUSE PLANNING AND CONSTRUCTION

6.6. The open plan seen in the U.S. is popular and usual in Canada and basements are common. Two-storey houses are more usual than in the U.S.A. and there appear to be more semi-detached houses. Fairly high standards of heat insulation are common in new housing and storm sashes are considered almost essential in the colder districts. (In Toronto they were regarded as desirable but were not very common in the small houses, whereas in Montreal they were quite normal.)

HOUSE HEATING

6.7. Broadly speaking house heating methods are the same as in the colder areas of U.S.A. but vary considerably according to district. Open fires are used only as decorative features and even in Vancouver and Victoria over half the houses are heated by warm air furnaces and the open fire as a means of providing heat is taken no more seriously than it is in Seattle and Portland, where the temperatures are similar. Gravity warm air systems are most common with a tendency for forced air systems to be used in new housing when they can be afforded. In Quebec there is a strong preponderance of solid fuel space heaters using timber or coal. These are of the so-called " Quebec " type commonly situated in the living room. In some cases there may be more than one stove in the house but frequently other rooms are warmed by taking through them an iron flue pipe from the one stove; this flue pipe is often diverted through several rooms in order to obtain the maximum heat from it. In summer the flue pipe is usually dismantled and stored, partly for the sake of appearance and partly to prevent deterioration by rusting as a result of condensation in the pipe. We were told that wartime house heating would be mainly by space heaters in the ordinary American sense.

6.8. The use of mechanical blowers on basement furnaces was increasing as they enabled the cheap home-produced coal to be used instead of imported anthracite.

6.9. Gas and electric fires are not widely used except perhaps for between season conditions and they are the exception rather than the rule. The gas fires were the radiant type often without flues and they had not been developed to the same high standards as the modern English gas fire.

6.10. It was very interesting to compare the attitude towards electrical development in Ontario with the attitude adopted in the Bonneville area of Oregon, U.S.A. In both places electricity for domestic purposes has been developed to a considerable extent for cooking and water heating, but in Bonneville where they expect a surplus of power after the war they are experimenting with the use of electricity for house heating (*see* 8.24). Ontario on the other hand with a reduced winter water flow appeared to be anxious to avoid such developments.

COOKING

6.11. Gas cookers are more numerous than electric, though the latter are gaining in popularity. Solid fuel is used to some extent, more particularly in Quebec where the cooker is also used as a partial source of room heating. Gas and electric cookers are very similar to those in U.S.A. but we were told that in Canada rather less importance is given to speed and more to thermal efficiency.

WATER HEATING

6.12. Water heating may be either from a coil in the space heating furnace, from a small separate boiler or from gas or electric appliances. One development of interest was in Toronto where the supply company had installed some hundreds of electric water heaters in storage tanks and supplied current at off-peak periods at a standard charge per month. This standard charge included installation, maintenance and current during the off-peak period. Sometimes there was an additional heater unit in the tank, controlled by the tenant, and charged at ordinary rates.

WASHING MACHINES

6.13. In the Ontario area we had confirmation of the same popularity of electric washing machines that we had found in U.S.A. Taking " saturation " as being the total number of private dwellings equipped to use electrical appliances we were informed that whereas electric cookers were just over 30 per cent. of " saturation ", electric washing machines were up to 60 per cent. and, as in the U.S.A., the " boiler " was virtually unknown.

RESEARCH

6.14. Most Canadian firms and professional bodies are members of U.S. Associations and the American Society of Heating and Ventilating Engineers includes Canadian members. It is therefore inevitable that a good deal of research work undertaken in the U.S. is directly available to Canada. Of the work being done in Canada, we were only able to see Toronto University where we were impressed with the work of the Department of Mechanical Engineering.

STATISTICS

6.15. We cannot emphasise too much the importance of the work being done by the Central Bureau of Statistics. This organisation was set up during the 1914–18 war to co-ordinate all the statistical information of the Dominion at war and was never disbanded but in fact extended. The work of the Bureau is comparable with the Central Statistical Office in this country except that it covers all economic activity in the Dominion. The Canadian Office endeavours to provide information on the different heat installations in every province.

Chapter 7

SOME TECHNICAL DETAILS OF SPACE HEATING APPARATUS IN COMMON USE IN U.S.A.

GENERAL

7.1. In Chapter 1 we gave a general description of the methods of space heating which are in common use. In this chapter and in Chapters 9 and 10 we give some of the more important details of appliances. It should be noted that the descriptions refer to the types of appliance which were being used in new installations immediately before the war and not to types which may exist in many old houses nor to developments at present under consideration and which may be seen in post-war models. The descriptions apply to appliances with a rated output of about 30,000 to 40,000 B.Th.U. per hour. The " Specification Requirements " given below are either existing or proposed standards prepared by the Bureau of Standards except in the case of gas appliances for which the standards were sponsored by the American Gas Association.

SPACE HEATERS

7.2. *Extent of use :* Used in 47 per cent. of all houses and 35 per cent. of urban houses, chiefly in houses of lowest income group. Being displaced by warm air heaters.

7.3. *Brief description :* Consists of a firebox lined with metal or refractory which may or may not be surrounded by a case ; cased heaters such as that illustrated in Fig. 1 (p. 7), are displacing the older uncased type.

7.4. *Applicability :* To small houses of compact design, preferably with open internal plan ; basement not necessary.

7.5. *Location :* In living room and centrally situated in house.

7.6. *Service :* Full heat to living room ; warmth to rest of house by somewhat fortuitous distribution.

7.7. *Typical dimensions*—for cased heater for small house :—

Height 50 in. Width 28 in. Depth 20 in.
Firebox 22 in. by 12 in. by 11 in.
Smoke pipe 7 in. diameter.
Total weight 500 lb.

7.8. *Materials :* Usually cast iron or alloy firebox, with sheet metal outer casing.

7.9. *Fuel :* Chiefly coal, coke or wood ; oil and gas also used.

7.10. *Stoking :* Chiefly hand-fired.

7.11. *Grate :* Usually shaking.

7.12. *Control of burning :* Usually manual ashpit damper, flue damper and spoil draught in flue or charging door.

7.13. *Air circulation :* Usually gravity ; in some cased models a fan is fitted to force the air downwards to discharge it near floor level giving better temperature distribution in room.

Specification Requirements for Solid Fuel Space Heaters

7.14. *Efficiency :* Not less than 55 per cent. for hand-firing and not less than 50 per cent. for magazine feed.

Attention interval : Hand-fired 6 hours, magazine feed 12 hours.

Banking period : Hand-fired 12 hours, magazine feed 24 hours.

Special requirements : At full output the temperature of jacket (if used) not to exceed 400°F. except within 6 in. of firing door, door frame, top grille or flue pipe. Flue gas temperature not to exceed 900°F. and metal temperature not to exceed 1,000°F. or red heat. Draught for full output not to exceed 0·06 in. water gauge.

Minimum rate of combustion : Not to exceed 25 per cent. of the rate of combustion at full rated output.

Test fuel : Chestnut anthracite.

Other comments : Very little attempt seems to be made to reduce the overall size of this type of appliance.
Until the above proposed standard was put forward through the Bureau of Standards little attention was paid to minimum rate of combustion.

PIPELESS WARM AIR HEATERS

7.16. *Extent of use :* Used in 3·5 per cent. of all houses and 3·3 per cent. of urban houses, chiefly in houses of the fairly low income group.

7.17. *Brief description :* Consists of a furnace situated below floor level and surrounded by a jacket through which air passes thence through a grille in the floor to find its way through the house and back to the inlet of the heater for re-circulation. Fig. 2 (p. 8), is an illustration of one type of pipeless warm air heater.

7.18. *Applicability :* To small houses of compact design with open internal plan. Basement necessary for solid fuel type but pit only required for gas or oil type. Rooms must be suitably located around outlet grille.

7.19. *Location :* Solid fuel type. In centre of basement with discharge grille in floor immediately above. Gas and oil type may be in pit (or suspended on basement ceiling) in centre of house. The heaters located in a pit are known as floor furnaces.

7.20. *Service :* Complete heating of whole house.

7.21. *Typical dimensions and materials of Heater for small house.*

(i) for solid fuel type basement heater—

90 in. high, 36 in. diameter.
Grate 14 in. diameter.
Firepot 18 in. diameter, 11 in. deep.
Smoke pipe 8 in. diameter.
Total weight 900 lb.
Register size 26 in. by 26 in.

Materials : Cast iron or alloy firepot. Cast iron or sheet metal casing.

(ii) for gas or oil fired type floor furnace—

38 in. long by 15 in. wide by 32 in. deep.
Total weight 135 lb.
Register size 18 in. by 32 in.

Materials : Sheet metal casing.

7.22. *Stoking of Solid Fuel Heaters :* By hand.

7.23. *Grate of Solid Fuel Heaters :* Usually shaking.

7.24. *Control of Combustion :*

(i) solid fuel—usually single remote control in living room operating ashpit damper and flue damper or spoil draught.

(ii) gas and oil—usually by thermostat, but can be manually controlled.

7.25. *Air circulation :* Usually by gravity. In the solid fuel heater the re-circulated air enters at the bottom of the furnace, passes through the jacket and passes out through the grille. In the gas or oil fired floor furnace the air both leaves and returns to the furnace through the floor grille.

Specification Requirements for Pipeless Warm Air Heaters

7.26. *Gas fired floor furnaces :*

Efficiency not less than 65 per cent. for gravity circulation ; not less than 70 per cent. for forced circulation.

Flue gas temperature not to exceed 530°F. above room temperature.

Other requirements : Air temperature limited to 350°F. above room temperature at 1 in. above grille.

Oil fired floor furnaces :

Efficiency not less than 70 per cent. for gravity or forced circulation.

Flue gas temperature not to exceed 780°F. above room temperature.

Carbon dioxide in flue gases not to be less than 10 per cent.

Draught to be between 0·02 and 0·06 in. water gauge.

Solid Fuel Heaters : We know of no specification for these heaters.

7.27. *Other comments :* A coil for water heating may be fitted to the solid fuel furnace.

GRAVITY WARM AIR FURNACES

7.28. *Extent of use :* There are no separate figures for gravity and forced warm air system but together they are used in 17 per cent. of all houses and 22 per cent. of urban houses. Gravity warm air furnaces have been used chiefly in houses of the middle income group but are finding an increasing use lower down the income scale, whilst in higher income groups there is a tendency for them to be replaced by hot water systems. Forced warm air systems are more usually found in higher income group houses than gravity warm air systems.

7.29. *Brief description :* Consists of a furnace surrounded by a jacket through which air passes, the warm air is conveyed through ducts to the various rooms of the house, it returns from the rooms for re-circulation either through return ducts or open doorways.

7.30. *Applicability :* To small and medium sized domestic houses of fairly compact plan and with basement.

7.31. *Location :* In basement preferably near centre of house.

7.32. *Service :* Complete heating of whole house.

7.33. *Typical dimensions for solid fuel gravity warm air furnace for small house :*

Diameter 40 in. Height 7 ft.
Smoke pipe 8 in.
Fuel pot diameter 20 in., depth 11 in.
Weight 950 lb.

7.34. *Materials :* Usually cast iron or alloy firebox with sheet metal casing and ducting.

7.35. *Fuel :* Chiefly coal ; oil and gas also used.

7.36. *Stoking :* Usually hand-fired.

7.37. *Grate :* Usually shaking.

7.38. *Control of burning :* Usually by room thermostat operating ashpit and chimney damper or spoil draught.

7.39. *Specification requirements for Gravity Warm Air Furnaces :*

Efficiency : (i) Pot type oil burner, 70 per cent. ; (ii) gas, 70 per cent.

Flue gas temperature : (i) Pot type oil burner, 300°F. to 920°F. above room temperature ; (ii) Gas, 480°F. above room temperature.

We know of no specifications for solid fuel gravity warm air furnaces.

7.40. *Other comments :* The circulation of the air is produced by gravity and the power available is thus small, consequently the greatest care must be exercised in the proper design of the ducting system and positioning of outlet grilles. The distribution of temperature in a well-designed system is fairly satisfactory but with a bad design unequal heating, especially low temperature near the floor, is common. A coil can be fitted in the furnace for domestic hot water supply.

FORCED WARM AIR FURNACES

7.41. *Extent of use :* This has already been given in paragraph 7.28.

7.42. *Brief description :* Consists of a furnace surrounded by a jacket through which warm air is forced by means of a fan ; the warm air is conveyed through ducts to the various rooms of the house ; it returns from the rooms to the furnace for re-circulation, usually through ducts, although in some cases return is through open doorways.

7.43. *Applicability :* To any house of a reasonably compact plan with or without basement.

7.44. *Location :* Preferably in a fairly central situation. Usually it is located in the basement ; if no basement, in utility room or " cupboard " on ground floor.

7.45. *Service :* Complete heating of whole house with air filtration if desired.

7.46. *Typical dimensions for solid fuel forced warm air furnace for small house :* About the same as for a gravity warm air furnace but may be slightly smaller.

7.47. *Materials :* Usually cast iron firebox with sheet metal casing and ducting.

7.48. *Fuel :* Chiefly coal ; oil and gas also used.

7.49. *Stoking :* Usually hand-fired, but installation of mechanical stokers is increasing in larger houses and particularly where this enables cheaper coal to be used.

7.50. *Grate :* Usually shaking.

7.51. *Control of burning :* By either room or bonnet thermostat operating ashpit damper and chimney damper or spoil draught. [The bonnet is the space at the top of the furnace below the outlet manifold.]

7.52. *Specification requirements for Forced Warm Air Furnaces :*

(i) *Solid Fuel :*

Minimum efficiency : 55 per cent.

Flue gas temperature : not less than 830°F. above room temperature.

Flue draught : not more than 0·06 in. water gauge.

Attention interval : hand-fired, 8 hours or more ; magazine feed, 12 hours or more.

Banking period : hand-fired, 12 hours or more ; magazine feed, 24 hours or more.

Test fuel : chestnut anthracite.

Special requirements : Air temperature rise in bonnet at full output from 70°F. to 100°F. Firepot or other metal heat exchanger parts must not exceed temperature of 930°F. maximum above room temperature or 830°F. average above room temperature.

Jacket temperature not to exceed 230°F. above room temperature except at parts above firing door or within 6 in. of sides of firing door frame and flue collar.

Minimum rate of combustion : not more than 25 per cent. of that at maximum output.

(ii) *Gas :*

Minimum efficiency : 75 per cent.

Flue gas temperature : not more than 480°F. above room temperature.

Discharge air temperature : from 70° to 100°F. above room temperature.

Heating element temperature : not to exceed 875°F.

(iii) *Oil :*

Minimum efficiency : 72 per cent.

Air temperature rise : 90° ± 10°F.

In the oil and solid fuel tests the air velocity and temperature at the filter are limited.

7.53. *Other comments :* The control of heating can take a variety of forms ; it is exercised primarily from a room thermostat, with secondary control by means of a bonnet thermostat. In some cases fan operation is intermittent whilst in others it is continuous. With intermittent fan control the system acts as a forced system when the fan is on and a gravity system when the fan is off ; this causes distribution difficulties especially in two-storey dwellings, because for satisfactory operation of a gravity system the ducts to the upper floors should be of smaller cross section than those to lower floors (for the same heat throughput), whilst for a forced system the reverse is the case. With intermittent fan operation some compromise is necessary. With continuous fan operation the temperature of the air may become so low during periods of low heat requirement that cold draughts are produced unless extreme care is exercised in locating inlet and outlet grilles.

A heating coil for domestic hot water may be used with forced warm air furnaces.

HOT WATER AND STEAM HEATING

7.54. *Extent of use :* These are used in 22 per cent. of all houses in the U.S.A. and 33 per cent. of urban houses. They are found chiefly in multiple buildings and in individual houses of the highest income groups, although there appears to be a tendency for their increased use lower down the income scale.

7.55. *Brief description :* They follow the several systems well known in this country and no further description is necessary except to say that thermostatic control from a room thermostat is general. Special developments are dealt with in Chapter 8.

OTHER FORMS OF SPACE HEATING

7.56. In the whole of the United States 89 per cent. of the houses rely on steam, hot water, warm air systems or space heaters as their main source of heating. The remaining 11 per cent. have no heating (for example, in the extreme South of Florida) or depend upon fireplaces or other appliances.

Chapter 8

DESCRIPTION OF OTHER METHODS OF HEATING INCLUDING DEVELOPMENTS AND EXPERIMENTAL WORK

GENERAL

8.1. In Chapters 1 and 7 we have described the methods of warm air, water and steam heating which are in common use. In this Chapter we give a brief description of various methods of heating or types of appliance which we saw either in use or in fairly advanced stages of experiment or development.

FIREPLACES

8.2. As we have said elsewhere the ordinary fireplace is not considered seriously as a principal method of heating in any of the colder or temperate areas of the U.S.A., although it is used for its decorative value in which case the fuel used is mostly wood.

8.3. In some areas, however, there is still a sale for types of open fire which combine convection with radiation and in general principles these are not unlike developments which have been made recently in England, although in some districts of U.S.A. they have been used for many years.

8.4. The commonest form of these " convector " fires consists of a dog-grate which stands in a sheet metal fire surround. The sheet metal surround is double walled and air between these walls is warmed. Inlets from the room to this " heating chamber " are provided at low level and outlets at high level. The heating chamber extends around both sides and the back of the fireplace. Fig. 7 (p. 53) shows the metal fireplace unit which is normally built into an ordinary chimney breast. It should be noticed that the unit includes the throat and gathering, so that with good design there should be no difficulty with smoky fires which are liable to occur with badly detailed or poorly built brick construction. It is also noticeable that there is a controllable damper. Some form of damper is always provided in American open fires so that flues can be closed off to prevent heat loss when the fireplace is not in use or can be used to obtain some regulation of draught when the fire is in use.

Fig. 8 (p. 54) shows a back view of a more elaborate version of the same thing. In this case there is a high level outlet as well as outlets at mantel height, and there are also two small electric fans which draw air in at low level and, therefore, cause a more rapid circulation. These fans can be thermostatically controlled. In the appliance illustrated air filters and also a humidifier may be incorporated.

8.5. These convector fires seemed to be used to some extent for heating small week-end cottages or as supplementary heating combined with other methods rather than as the sole means of heating of normal houses, except in the warmer climates and even there the tendency is to eliminate open fires in favour of more labour-saving methods.

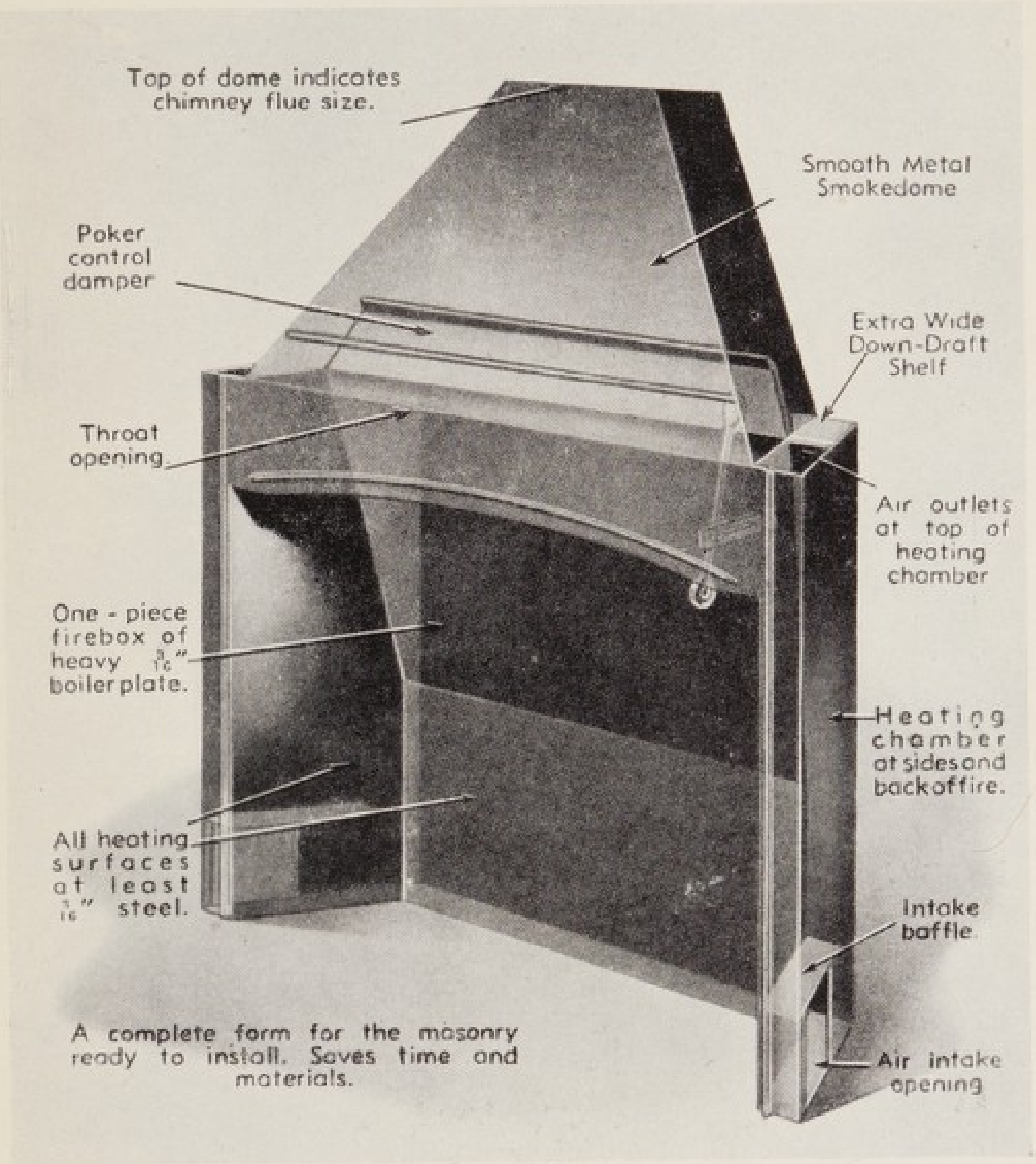

FIG. 7. Convector Type Fire.

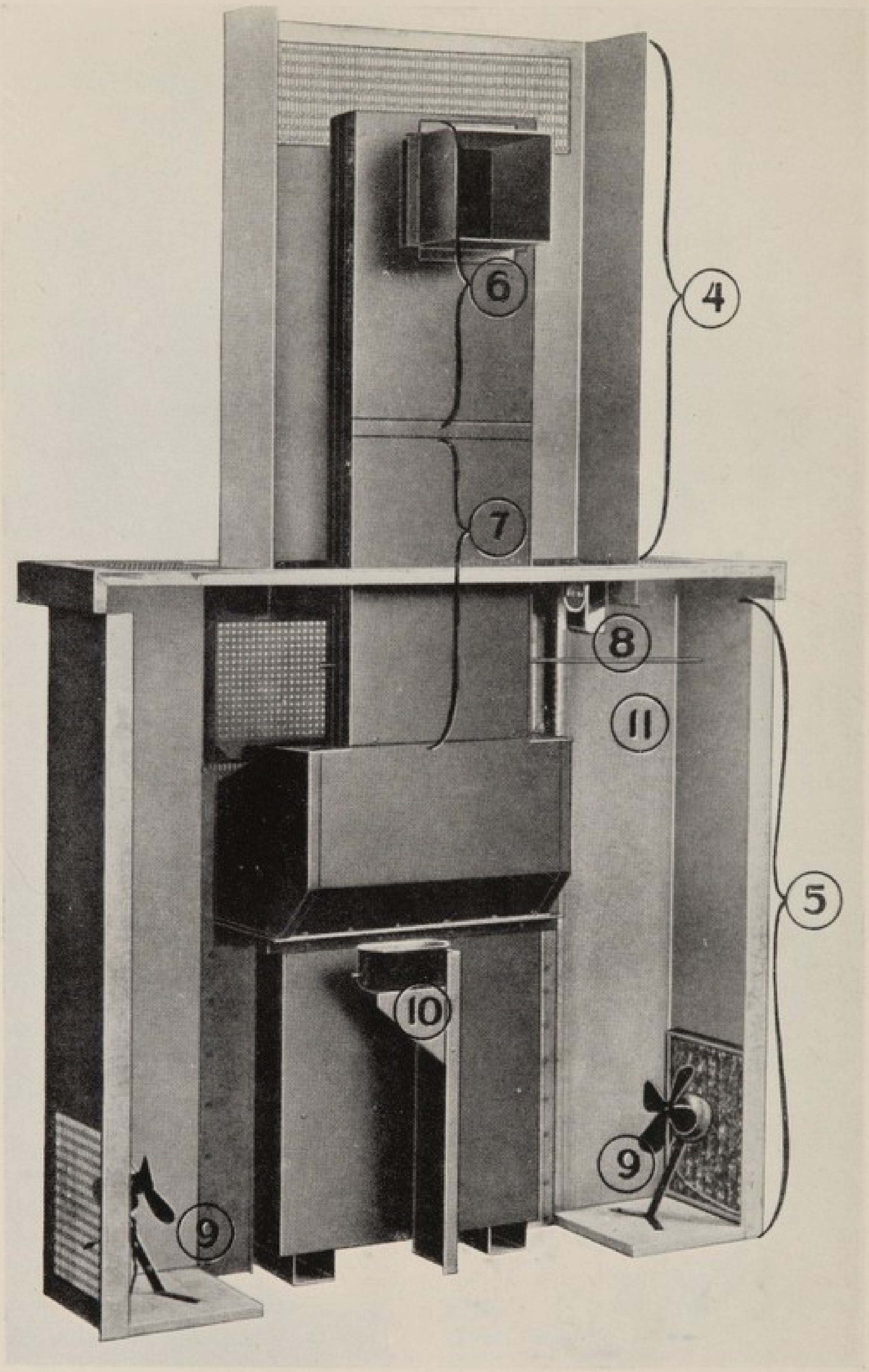

FIG. 8. Convector Type Fire including high level air outlet, humidifier and fans with thermostatic control.

CHIMNEY FURNACES

8.6. The chimney furnace consists of a heater fired by solid fuel, gas or oil placed immediately below a straight chimney. The chimney consists of a metal flue up which the flue gases pass. Around this flue is an air space which is enclosed either by a brick chimney or by another metal pipe. Heat is transferred from the flue gases through walls of the inner flue to the air surrounding this. This warm air is then transferred to the house either by a natural upward flow by gravity, or, more usually, by a forced downward flow provided by means of a very small electric fan at roof level, the air being blown down and then out of air gratings as in a normal warm air system. Return ducts would be provided to the roof space in the case of a forced system. A maximum air velocity of 700 ft. per minute in the chimney round the flue and 300-400 ft. per minute at outlets was said to be used.

8.7. In oil and gas burning chimney furnaces baffles are fitted at 2 ft. intervals up the chimney to increase the heat transfer, with gas furnaces a downdraught baffle is fitted at roof level. The general arrangements of the system is shown in Fig. 9 (p. 56).

8.8. The inner flue is of galvanised iron or porcelain enamelled iron, the latter being used whenever there is a gas furnace. This type of flue which is said to be cheap and satisfactory is described in more detail in Chapter 12 on "Chimneys" as it is used for other purposes besides the Chimney Furnace. Two points which might be noted here, however, are first that the flue is often made of short lengths of tapered pipe; this is to allow economic packaging, a matter of considerable importance in transporting long distances and, second, there is an expansion joint fixing at the top of the flue.

8.9. The inventor of the Chimney Furnace proposed to licence manufacturers to produce it and he was fully aware of the dangers of such a simple apparatus being badly made or badly installed. A considerable number of installations have, in fact, been made in widely separated districts and there have been a number of troubles reported. It appears to us that these were largely due to the adoption of the idea on too large a scale before all the incidental details had been fully tried out. To some extent this was undoubtedly due to war conditions.

8.10. We examined one installation on an estate where a number of solid fuel chimney furnaces had been used in single-storey dwellings. So far as we could tell this worked satisfactorily although the noise from the fan or from the air flow down the chimney appeared to be somewhat more than would be liked by many people.

8.11. Among the claims made for the chimney furnace are that it is cheaper than normal warm air furnaces, that it is easier to install, that it is safer and that it is more efficient and gives a quicker response. Also that it takes up less space. The last claim is certainly correct but confirmation of the other points is required. In view of the considerable number installed in U.S.A. the possibilities of this type of appliance should be investigated in this country by trial installations. There is said to be development of a somewhat similar kind being tried in this country and in this case it should be considered in

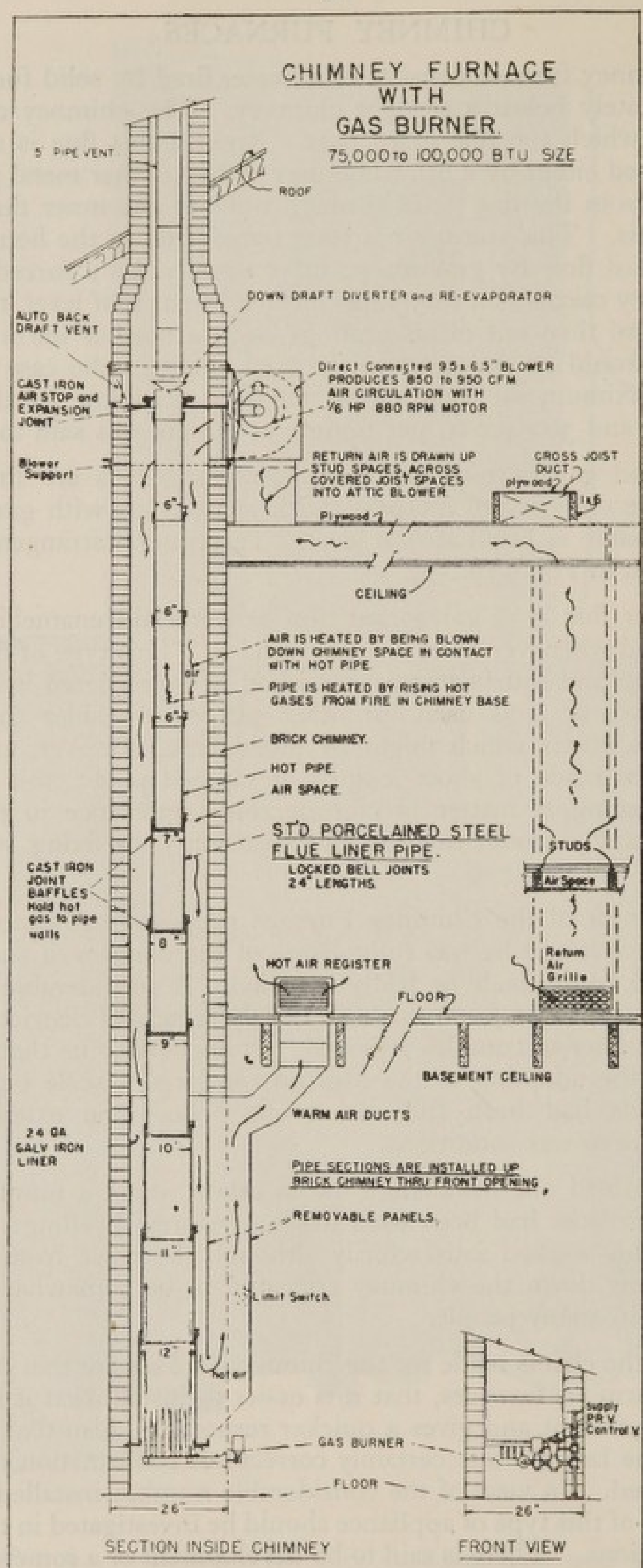

FIG. 9. Chimney Furnace.

conjunction with the system we have described. There seems to be no reason why this method of warm air heating should not be combined with some high temperature radiant heating by using an openable type of solid fuel stove as the source of heat.

PANEL HEATING

8.12. *General.*—Under the heading of panel heating we include any of the systems of low temperature radiant heating which we saw. These included both floor and ceiling heating with heat supplied either by hot water or warm air.

8.13. The total amount of such heating in private houses was not great and was mostly confined to medium or high income groups, but the interest displayed in these methods was quite considerable, and it seemed that there was a very real possibility of appreciable development taking place in the future.

8.14. *Comfort conditions.*—In the few cases where we were able to see installations actually working we found the householders most enthusiastic about panel heating. They were all very satisfied with it from the point of view of comfort except in one case where it was installed in flats and where, owing to wartime conditions, there was no means of control of temperature by individual flat occupiers. Its cleanliness was regarded as an important feature and in some cases the absence of any obstruction to furniture was commented on.

In the few examples we saw we did not find that dry bulb temperatures were kept lower than in houses with other forms of heating. It was very interesting however, to find that everyone was convinced that with floor panel heating a floor surface temperature of 80°F. was perfectly comfortable and many people were satisfied that floor temperatures up to 85°F. were satisfactory. In England a floor space surface temperature of about 70°F. or a maximum of 75°F. has been regarded as the limit permissible for comfort, and, therefore, further investigation seems to be required, since with an increase in permissible floor surface temperature it would be possible to use floor heating alone in cases where this would be impossible with a 70°F. surface temperature limit.

Types of Installation.

8.15. (a) *Floor heating by warm water.*—We did not see or hear of any examples which differed from the normally accepted methods except that in some cases we were told of installations where circulation was from a feeder pipe across a series of small branches to a return pipe rather than through the more usual kind of S coils. There were no fundamental data on heat losses from solid ground floors, nor any generally recognised standard for under floor insulation in such cases. (We refer in Chapter 13 to experimental work at the Bureau of Standards and at Purdue University on heat losses from solid ground floors.)

8.16. (b) *Floor heating by warm air.*—We saw in Chicago an example of floor heating by warm air. The construction of the floor consisted of hollow clay blocks laid to form continuous ducts through which warm air was circulated from a normal warm air furnace with electric fan attached. This system had been adopted in place of water circulation through pipe coils because of the war shortage of metal, but the architect responsible was so satisfied with the result that he said he would adopt this method in future work.

8.17. We were told of another warm air floor heating system where the air was circulated in an under floor space with inlets at one side of this and outlets to a return duct opposite and this also was said to be satisfactory.

8.18. (c) *Combined floor and ceiling heating by warm air*—Two blocks of two-storey flats were seen near Detroit in which warm air panel heating was used. Hot water from a thermostatically controlled solid fuel boiler, situated in a basement, circulated through a heat exchanger placed at the bottom of a main vertical duct. Air from the basement passed through the heat interchanger and thence through the duct to spaces over ground floor and first floor ceilings to return ducts and back to the basement which acted as a plenum chamber. A closed circulation between return and flow ducts had been tried and was said to have been unsatisfactory, but we were not able to find anyone who could explain this point. There were fire link closures to the ducts leading from the basement. In the case of upper floor rooms only part of the ceiling area was heated because these rooms received an appreciable amount of heat by upward leakage from the ground floor ceiling heat. Ducts in walls were lined with fire resistant building board and in some cases with heat insulating material. The flow of warm air over ceilings was arranged by covering the underside of ceiling joists with fire resisting building board and then forming an air space of about 3 in. below which there was a suspended ceiling. The system appeared to work satisfactorily except that in some cases there was insufficient insulation around the main flow duct in the walls with a result of some overheating in parts of the building. Fuel consumption was not available for a full heating season, but the owners of the flats expressed complete satisfaction.

8.19. At Utica there is another somewhat similar scheme. Air is circulated in an under ceiling space of 3½ in. formed by special hangers. This space is baffled by thin metal sheet so as to force the air to travel first round those portions of the ceiling nearest to the external walls. Maximum temperature of the air at the heater was said to be 140°F. and to vary from 135°F. down to 85°F. in the ceilings. Temperature gradients in a test house were 5½°F. from 3 in. above floor to 3 in. below ceiling. It was said that there were no complaints of stuffiness or of discomfort from overhead heating.

8.20. (d) *Large windows and panel heating.*—It was noticeable that in several houses having panel heating there were very large glass areas. This may have been due to the fact that the designers who were prepared to explore the value of panel heating were also those who were prepared to try out new ideas generally, but it was also claimed that with panel heating there was less tendency to notice cold air currents from glass areas. Whether the combination of large glass areas and panel heating leads to fuel economy is one which might require investigation.

8.21. In a number of discussions we came to the conclusion that many people would like to have panel heating, but feared that for the time being it would be too costly in installation for the small house. Many times it was suggested to us that the system was an English one and that we had more experience here than the Americans. In order to keep abreast of development some experimental installations might be made in this country and in view of our variable climatic conditions here, in the first instance, might be on the lines of the warm air panel methods described as with these the response to changes in temperature would be more rapid. There was a fairly strong opinion that control of panel heating under American conditions should be by means of thermostats located outside the house. Whether this would be desirable in this country would require investigation.

SUN HEATING

8.22. In Chapter 13 some experimental work on solar heating which has been carried out at the Massachusetts Institute of Technology is mentioned. Although the work there was not intended to be of immediate practicable application to ordinary houses in a cold climate it was of considerable interest in showing the possibilities of obtaining heat from the sun. Elsewhere, however, we saw several examples of houses where large glass areas with a southern aspect were used deliberately to take advantage of sun heat. In one case we stayed in such a house and were impressed by the fact that on a day with an outside temperature well below freezing the heating system was shut down by the thermostat from about 9.30 a.m. until early evening. The use of such large glass areas naturally involves the need for a proper arrangement for preventing overheating in summer. This is usually done by providing a projecting hood, often of open slat type, so arranged that it cuts out high angle summer sun while allowing full penetration of low angle winter sun.

If this large glass area is to be used to advantage there should be adequate curtaining or shuttering of some kind to prevent undue heat loss at night by radiation outwards from the rooms.

GAS AND ELECTRIC FIRES

8.23. In the colder areas high temperature radiant heating was virtually never used, even for supplementary heat. In the southern areas gas fires were used to some extent but elsewhere were not found even in districts where gas was cheap. Such examples as we saw were all of antiquated design. There was a similar absence of electric fires except in one or two areas where there was an abundance of cheap hydro-electric power.

8.24. The one interesting example of high temperature radiant heating which we saw was near Portland, Oregon, where the electricity authority was expecting a reduction in demand from war factories and was therefore trying to increase demand from other users. Houses were being fully heated by electric heaters run at or slightly below dull red heat and combined radiation with a considerable amount of convection. Each room had one or more electric fires built into the walls and each fire was controlled by a separate thermostat placed in the path of the inflowing convection air immediately below but shielded from the heater. In this way it was found that the electricity demand was spread more evenly. Each fire consisted of either two or three elements each of 1 kW. power. Each element could be switched on or off by hand control in addition to the thermostatic control. The element consisted of coils wound round vertical hollow fireclay columns and behind these was a metal reflector. Air passed up around and through the hollow fireclay columns and also up behind the metal reflector. We were told that the air left the heater at about 200°F. and at a speed of about 180 ft. per minute. The radiant component of the heat was about 15 per cent. There was a baffle plate incorporated at the top of the unit to prevent dirt staining of the wall above.

8.25. In the houses examined we found the occupiers very satisfied with this method of heating and we also found that the temperature gradient from floor to ceiling was very small. People did not sit around the fires as the whole room was warm. (In living rooms there were always two fires.) The temperature immediately in front of the fires was sufficiently high to make it impossible to place furniture very close and in this respect it was fairly similar to our British type high temperature radiant heater. It was noticeable that in the case of bedrooms this did mean more restriction in the arrangement of bed position than would be the case with a warm air heating system.

CERAMIC STOVES

8.26. The ceramic stove of the "Kacheloven" type used so commonly in Northern Europe has not been adopted in America and we saw only one development of this kind. The Pittsburg housing authorities had designed a heater of this type for a wartime housing estate in order to economise in metal.

8.27. The heater, as installed at Pittsburg, consists of a brick and tile chimney with a grate and firebox at its bottom. A series of fireclay baffles is used at intervals above the firebox. The chimney is designed to pass through both storeys of a two-storey house in an interior location so that the maximum exposure is obtained from the chimney surfaces to the house. Heating is by convection and radiation to the rooms on both floors of the house. The general arrangement of the heater can be seen from Fig. 10 (p. 61).

8.28. The heater had been installed in about 300 houses and appeared to be giving reasonable satisfaction. As now installed the surface temperature is usually between 110–140°F., but apparently during the earlier developments much higher temperatures had been reached and because of this the convection heating was incorporated. With the original flues the chimney draught proved too great and this had to be reduced by cutting down the outlet size at the top of the stack. There had been a little trouble from cracking of the glazed tiling due to shrinkage but this had not been serious. Sweeping of the baffles was done from a series of soot doors.

8.29. The chief difficulty appeared to be that tenants had not really learned how to operate the stoves completely successfully. They tended to run the stoves at a high rate of burning until the rooms were fully heated, forgetting that when they then slowed down the actual fire that the heat stored in the bricks and tiles would still continue to be given off into the house. The result was a certain amount of overheating and consequently some wastage of heat.

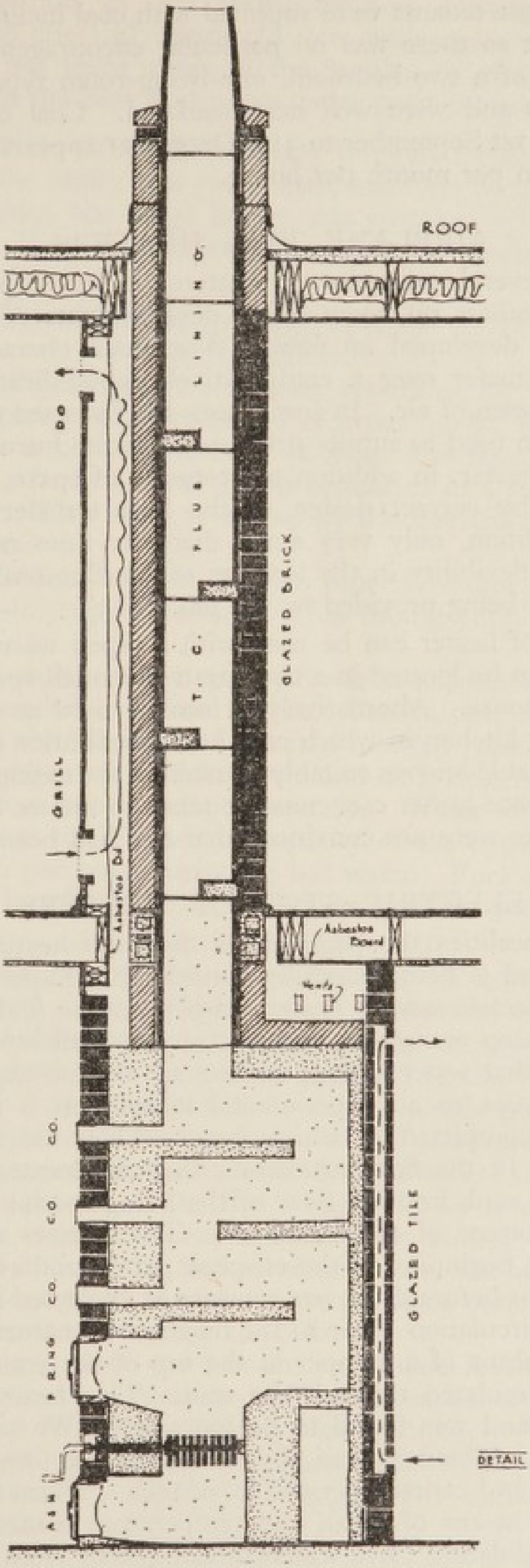

FIG. 10. Ceramic Stove or " Kacheloven."

8.30. On this estate tenants were supplied with coal included as a standard charge in the rent so there was no particular encouragement to economy. The houses were of a two-bedroom, one-living-room type and were fitted with storm sashes and were well heat-insulated. Coal consumption over four months from 1st September to 31st December appears to have averaged a little under $\frac{3}{4}$-ton per month per house.

AIRPLANE TYPE HEATERS

8.31. We saw several examples of heaters of the airplane type, some burning gas and others oil, some being developments of airplane heaters and others being developed *ab initio.* The main characteristic of these heaters is heat transfer over a comparatively small heating surface to a rapidly moving stream of air. In some cases the fan used to provide the air movement was also used to supply primary air to the burner. It is claimed that with such a heater, in addition to economy of space, a high efficiency can be obtained by correct design of the heat transfer surface and air channels. In addition, only very small diameter flues need be used and there is a greater flexibility in the location of the flue outlet as gas flow in the flue is positive being provided by the fan.

8.32. This type of heater can be used with a piped warm air distribution in which case it can be located in a comparatively small space in a cupboard anywhere in the house. Alternatively, it can be used as a space heater in the living room or kitchen in which case heat distribution can be controlled by means of adjustable louvres suitably situated in the casing of the appliance. When used as a space heater care must be taken to reduce fan and air noises to a minimum ; we were not convinced that this had been achieved.

ELECTRIC STORAGE HEATERS

8.33. In some localities the problem of domestic heating in relation to electricity peak load is being carefully considered. Experiments are being carried out with electric storage heaters with a view to finding a satisfactory heater which is cheap enough in capital cost for small houses. Experience so far has shown that water storage heaters are far too expensive in capital cost for small houses so an experimental installation is in operation and another is being completed in which large pebbles are used as the heat storage medium. In the first installation they are located in an insulated container partially sunk into the floor of the living room ; strip heaters are situated at the bottom of the container. The heaters are automatically switched on at the beginning of the off-peak period and switched off at the end of the period or before if the temperature at a selected spot in the heater reaches 450°F. Circulation of air to the house is by natural convection and is controlled by means of a damper at the top of the container. Air from the house is re-circulated through the unit. This heater contained only 400 lb. of stones and was found to be too small. We saw a second unit being constructed. This was basically similar to the first but was located beneath the house and contained 7,000 lb. of rock. Warm air was circulated through ducts by means of a fan and temperature control of the air was by means of a modulating valve which mixed hot air from the furnace with air from the house.

8.34. The installation of too many off-peak heating systems would obviously have the effect of creating a new peak and of defeating its own object. A study was being made of the number of off-peak heating units required to provide the best load curve under practical operating conditions.

LOAD LIMITING COOKER AND WATER HEATER SWITCH

8.35. In one public utility area the electric load was limited by a switching arrangement in which the water heater was switched off when the cooker was switched on. We do not know either the users' reactions or the effect on the load.

VERTICAL TYPE COMBINED HEATING AND HOT WATER APPARATUS

8.36. A combined heating and hot water apparatus Fig. 11 (p. 64) which was in the development stage consisted of a pot burner fired either by gas or oil. From this a vertical chimney of 6-in. flue pipe is surrounded to a height of about 5 ft. by a water jacket contained in a second metal jacket of 14-in. diameter. This water is heated by the flue and supplies the space heating by radiators.

In this water jacket and around the flue pipe is wound in spiral form an 85-ft. length of $\frac{3}{4}$-in. copper tubing. This tubing supplies the hot water for domestic use.

Outside the 14-in. casing is 1-in. glass fibre heat insulation and outside this an air space surrounded by a final jacket. Combustion air is drawn down this air space from the house attic by means of a fan beneath the apparatus. The apparatus is expected to deliver at least $12\frac{1}{2}$ Imperial gallons of hot water in 5 minutes at 100°F. temperature rise. Water for radiator heating leaves the furnace at 195°F. and the capacity of the apparatus was said to be 50,000 B.Th.U. per hour, including hot water. Fuel consumption with the model we saw burning oil was ·37 Imperial gallons per hour.

ANTHRACITE BURNER

8.37. Anthracite Industries Inc. are developing an anthracite burner in which fuel is burned at very high rates of combustion per unit of cross-sectional area. Combustion takes place in a tube of about 6 in. diameter and 18 in. long. Anthracite is fed into one end of the tube by means of a screw or plunger feed ; the fuel burns in the middle portion of the tube and ash is discharged at the other end. Air for combustion enters at the ash end and flue gases are abstracted near the feed end of the tube by means of an induced draught fan in the flue. Water or air is circulated around the hot part of the tube by means of a circulator pump. It is hoped that a single motor will operate the feed mechanism, the fan and the circulator. A unit weighing about 75 lb. is said to have the same output as a traditional domestic heating furnace weighing 1,000 lb.

The rate of burning is from 50 to 60 lb. per square foot of cross-sectional area of the tube per hour as compared with a maximum of 10 lb. per square foot of grate area per hour in an ordinary heating furnace. The heat transfer to the water or air in the jacket is about 40,000 B.Th.U. per hour. A high efficiency of combustion is claimed. The output is varied by intermittent operation of the motor.

This appliance is in an advanced state of development and a number of manufacturers are working on its application to domestic space heating and water heating.

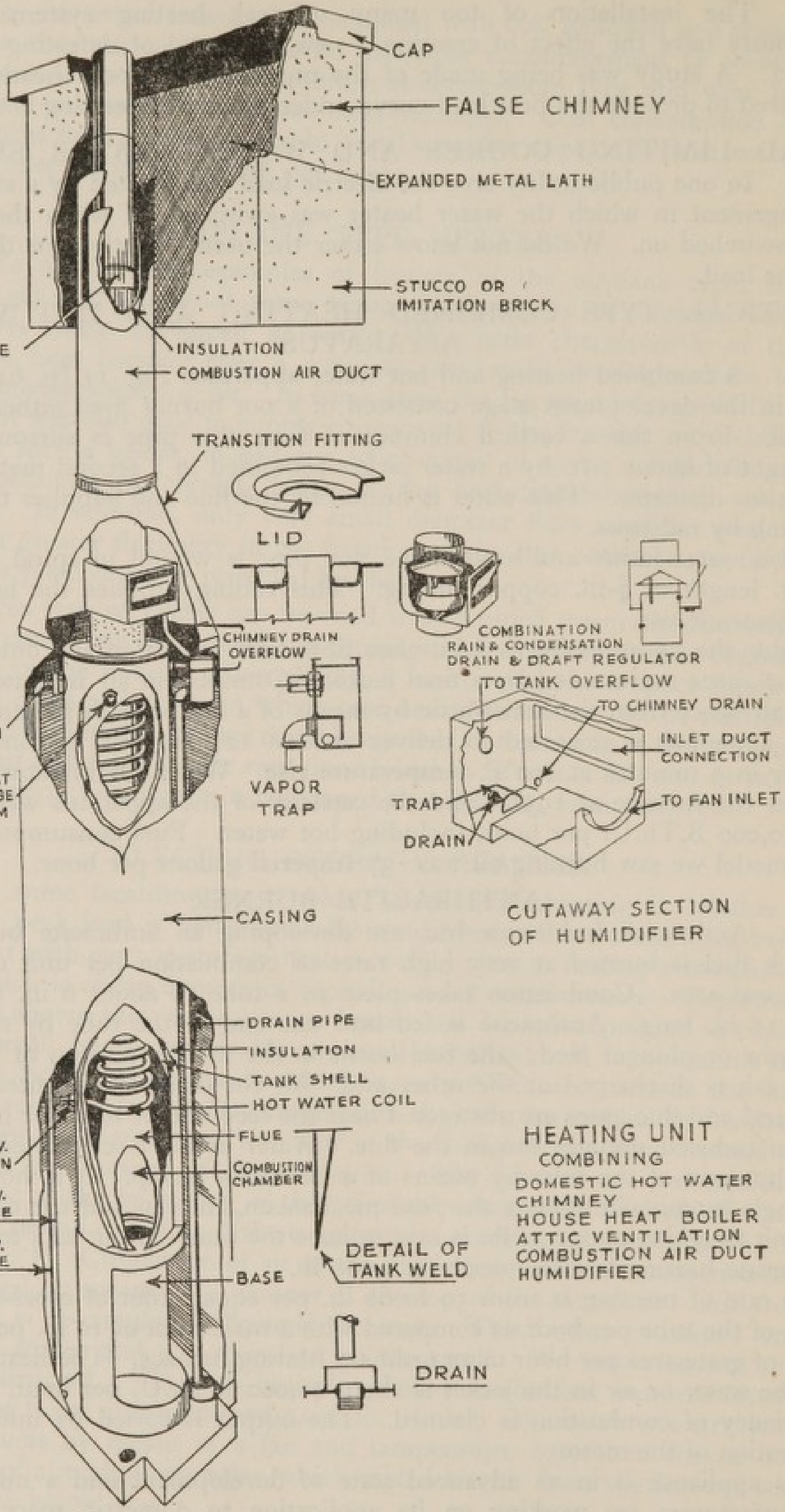

FIG. 11. Chimney Heater for Space Heating and Water Heating.

Chapter 9

SOME TECHNICAL DETAILS OF WATER HEATERS

GENERAL

9.1. Water heating requirements and a general description of methods are given elsewhere in this Report. We give below some technical details of the types of apparatus in common use.

Water heaters are usually situated in the basement, with the storage tank near them and not in airing cupboards, which are unknown because of the low winter humidity in most parts of the U.S.A. and because houses are generally warmed throughout. Water heaters are normally connected direct to the water mains and work under mains pressure.

WATER HEATING FROM SPACE HEATERS AND COOKERS

9.2. *Extent of use :* in 10–15 per cent. of urban houses. The water is heated by means of a boiler which forms part of the side of the firepot or by means of a coil situated in the combustion space.

SOLID FUEL WATER HEATERS AS SEPARATE APPARATUS

9.3. *Extent of use :* in 10--15 per cent. of urban houses.
Illustration : See Fig. 12 below.

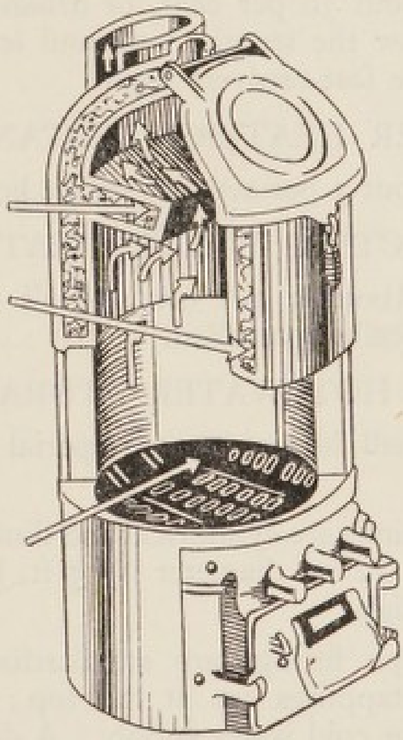

FIG. 12. Solid Fuel Water Heater, with water circulating around and about the combustion space.

The firepot is usually firebrick lined with the water circulating around and above the combustion space. In some heaters the fuel space itself is water-jacketed as in British domestic boilers.

9.4. *Typical Specification of Small Heater :*

Firepot diameter	12 in.
Grate diameter	10 in.
Smoke pipe diameter	5 in.
Overall height	19 in.
Weight	90 lb.
Gallons (American) per hour ..	55
Suggested tank size	30–40 galls. (American)

9.5. *Control of combustion :* Either manual or by thermostat clamped on return circulation pipe and operating ashpit damper or flue damper and spoil draught.

GAS WATER HEATERS

9.6. *Extent of use :* Over 60 per cent. of urban houses divided as below.

Materials : Chiefly galvanised steel : some with glass linings, copper and alloys sometimes used.

GAS WATER HEATERS—SIDE-ARM

9.7. *Extent of use :* About 30 per cent. of urban houses. This consists of a burner and heating coil unit which is located adjacent to the storage tank with flow and return pipes to the top and bottom of the storage tank, respectively.

GAS WATER HEATERS—STORAGE TYPE

9.8. *Extent of use :* About 30 per cent. of urban houses. The burner is located immediately below the storage tank and is usually thermostatically controlled and it is of the fast-recovery type.

GAS WATER HEATERS—INSTANTANEOUS

9.9. *Extent of use :* About 3 per cent. of urban houses.

ELECTRIC WATER HEATERS

9.10. *Extent of use :* About 3 per cent. of all houses. Usually of the storage type, thermostatically controlled.

DOMESTIC HOT WATER STORAGE TANKS

9.11. *Capacity :* In small houses a 25 Imperial gallon tank is normally used.

9.12. *Dimensions :* All tanks are cylindrical and dimensions are standardised, viz. : 25 Imperial galls., 12 in. diameter by 5 ft. high; 33 Imperial galls., 14 in. diameter by 5 ft. high.

9.13. *Pipe fittings :* Pipe fittings are standardised. With the cylinder standing vertically two tappings are at the top ; one for the hot water draw-off and the other for cold water supply. A dip pipe extends from the cold water inlet tapping to near the bottom of the tank so that the cold water is discharged downwards into the tank near the bottom. There is sometimes a hole near the top of the dip pipe to prevent siphoning back. The flow and return pipe tappings are on the side of the tank about 9 in. from the top and bottom, respectively.

9.14. *Installation :* Tanks are usually installed vertically, thus giving good stratification although we saw a number installed horizontally. It was stated that it is fairly common to install larger tanks of 16 in. diameter or greater horizontally. Tanks may be installed horizontally to save space or improve circulation as the tank is situated in the same room as the heater.

9.15. *Insulation :* Tanks for use with solid fuel burning appliances are often sold uninsulated ; insulating jackets are obtainable to fit the standard tanks.

Chapter 10

SOME TECHNICAL DETAILS OF COOKING APPLIANCES

GAS COOKERS

10.1. *Extent of use.*—In 1940 gas was the main cooking fuel in 48·8 per cent. of all houses in the U.S.A. and 73 per cent. of urban houses.

10.2. *Materials.*—Generally sheet steel, much less robust than British cookers. Usually white porcelain enamel finish.

10.3. *General description.*—Sizes and designs vary considerably. A four-burner top is common with a side oven as illustrated in Fig. 13 (p. 71), the space underneath the burner top is fitted with storage drawers; the grill (known as the broiler) is generally under the oven burner, but occasionally may be fitted below the burner top in its own separate compartment. Sometimes the oven, with grill in it, is situated directly under the burner top. Cover plates are usually provided, but it is an open question as to how frequently they are used. Oven doors usually drop down with bottom hinges.

10.4. *Efficiency.*—American cookers are recognised to be rather less efficient than British cookers, but to satisfy a strong public demand are faster in action.

10.5. *Insulation.*—About 60 per cent. of gas cookers in use in U.S.A. have insulated ovens.

10.6. *Oven thermostatic control.*—About 70 per cent. of gas cookers now in use have thermostatic oven control.

10.7. *Use of burners and oven.*—It is estimated about 60 per cent. of the gas used for cooking is used for the boiling rings and the remaining 40 per cent. in the oven (which includes the grill.)

10.8. *Average age.*—A survey by the American Gas Association shows that 36 per cent. of the gas cookers are between two years and five years old and 28 per cent. are between six years old and ten years old, with 18 per cent. less than one year old and 17 per cent. older than ten years. Although we have no comparable figures for Britain, if available they would probably show the average age to be much greater.

Griller.—The reasons for locating the broiler in the oven are said to be (1) less odours, (2) increased size, (3) adjustable height.

10.9. *Other comments.*—Miscellaneous devices such as condiment sets are often incorporated on cookers as sales points.

The Sub-Committee on New and Improved Post-War Appliances of the Post-War Planning Committee of the American Gas Association states:—

> " Utility companies can greatly assist in arriving at this goal of standardisation in reducing the number of sizes and models of ranges by confining their insistence on minor changes in construction and design to the national and regional desires along this line rather than insisting on changes for local conditions and usability. This will greatly facilitate shaping the objectives of fewer models and sizes and will be most beneficial economically both from a manufacturing and marketing standpoint ".

A nation-wide survey made by this Committee showed that nearly 90 per cent. of the utility companies questioned considered that " low grade cheaply constructed gas ranges " sold in their market reflected adversely on gas service to an important extent. Nearly 80 per cent. of the companies favour a raising of the American Gas Association Approval Requirements.

10.10. *Gas cooker with solid fuel heater.*—In this appliance the oven can be heated only by gas. The solid fuel heater is an integral part of the appliance and is used for warming the kitchen; it usually has a ring at the top for heating saucepans, etc.

ELECTRIC COOKERS

10.11. *Extent of use.*—In 1940 electricity was the main cooking fuel in 5·4 per cent. of all houses in the U.S.A. and 5·1 per cent. of urban houses. The percentage is higher in certain localities where electricity is particularly cheap.

10.12. *General description.*—A three or four hot plate top with side oven appears to be most common. The space underneath the hot plate is utilised for storage; the grill is situated in the oven usually immediately beneath the top element. Oven doors are usually of the drop down type with bottom hinges. Fig. 14 (p. 71) illustrates a fairly typical example. Smaller cookers with the oven under hot plate are used in lower income groups.

10.14. *Hot plates.*—Tubular radiant hot plates appear to be coming into more general use. They are said to be very durable if properly made and more economical than the solid type (because of low heat capacity).

Heat control switches to give five or six speeds of heating are common and continuous controls are also coming into use.

10.15. *Grills.*—If the oven has two elements one is usually situated at the top with the grill under it. If it has only one element it is at the bottom of the oven space with the grill beneath it.

10.16. *Efficiency.*—Speed of operation is regarded by the consumer as being of greater importance than efficiency. We have no data on the efficiencies of American cookers as compared with British.

10.17. *Supply.*—Three-wire 115-volt line to neutral.

10.18. *Other comments.*—Time control for ovens is quite common in the better class cookers. Miscellaneous sales appendages such as condiment sets are often incorporated.

SOLID FUEL COOKERS

10.19. *Extent of use.*—In the whole of the U.S.A. 11·5 per cent. of houses use coal or coke fired cookers and 23·6 per cent. use wood. In urban areas 8·0 per cent. use coal or coke and 6·0 per cent. use wood. There will be some cases where there are gas or electric cookers in addition.

10.20. *Brief description.*—Self-setting continuous burning appliances with firebox on one side of oven and often low pressure (i.e., non-piped) water heater on other side. Large firebox for wood firing; continuous burning with coal. Storage drawer often located under oven. Front and sides finished in white porcelain enamel. Fig. 15 (p. 71) illustrates a fairly typical example. Water coil or boiler may be fitted for piped hot water supply. Firebox end, oven doors and fire doors are insulated. In some cookers, kitchen is heated by warm air which passes through a space at the firebox end of the cooker. This can be shut off in summer by a damper.

10.21. *Materials.*—Cast iron body and firebox; sheet steel back, sides and doors.

10.22. *Fuel Consumption.*—For cooking—3 to 4 lb.-hr. Overnight burning $\frac{1}{2}$ to $\frac{3}{4}$ lb.-hr.

10.23. *All purpose unit.*

Extent of use.—Only a few per cent. of all houses.

This unit provides water heating, room heating and cooking. There may be one or two fires; if there are two fires one would be used for space heating by warm air or hot water and the other for cooking and water heating. Fires are continuous burning.

GAS AND SOLID FUEL OR OIL COOKERS

10.24. *Extent of use.*—About 7 per cent. of all gas cookers can also burn another fuel. A single oven can be heated by either gas or solid fuel. Chiefly used where no other provision is made for kitchen heating. It is also popular with housewives who are accustomed to solid fuel but want to enjoy the advantages of gas. When solid fuel is used sufficient heat is given off from the appliance to warm the kitchen. When gas is used in an internal burner in the oven much less heat is given off to the kitchen.

(*Left*) Fig. 13. Gas Cooker.

(*Right*) Fig. 14. Electric Cooker.

(*Left*) Fig. 15. Solid Fuel Cooker.

Chapter 11

HEAT INSULATION

GENERAL

11.1. Under this heading is included the insulation of walls, floors and roofs and also the reduction of heat loss through windows by various forms of double glazing and the use of weather strip.

11.2. In all areas which were visited roughly north-east of a line from Washington D.C. to St. Louis and Chicago, there was a very general acceptance of the idea of applying insulation over and above that given by the ordinary requirements of construction. Apparently this general acceptance of insulation has developed very largely during the past 10 or 15 years until it is now well understood by the ordinary householder. However, the most usual answer to any enquiry as to the value of insulation was to the effect that it " increased comfort." In areas where weather conditions were fairly comparable with this country there was also an acceptance, in theory, of the value of insulation, but in practice in such areas the small house seemed to have insulation values somewhat similar to those found in an average pre-war English house.

ROOF INSULATION

11.3. A noticeable point was that roof insulation was nearly always considered more important than wall insulation and that it was always provided immediately above top floor ceiling level and not in or attached to the sloping roof. The roof space of a sloping roof would usually be deliberately ventilated, because without this it was found by experience that there was trouble from condensation. In addition the ventilation of the roof space was recognised as of value for summer cooling. The reasons for this stress upon the insulation of roofs before walls were not always clearly understood, but it seemed probable that it was largely due to the considerable importance of reducing summer heat. There is also the factor that since the entire house is heated to a high temperature the heat transfer through the roof would be proportionately greater than under present standards of heating in this country.

11.4. There appeared to be no difficulty in providing sufficient winter insulation for flat roofed buildings, but for summer insulation with flat roofs we were on several occasions told that results had been unsatisfactory owing to the high heat capacity of the roof resulting in a sufficient build up of heat during the day to cause considerable inconvenience at night. In considering this point it is necessary to bear in mind the fact that the U.S. summer temperatures are higher than in this country.

WALL INSULATION

11.5. The majority of houses in the districts visited were of frame construction, sometimes with a 4-in. exterior brick veneer. Insulation was either by means of " soft " materials as an interstud filling or by " rigid " materials as a wall lining. Where a stud filling type of material was used it was usually of a batt type in the case of new houses. Loose material was occasionally used for new houses but more commonly for the addition of insulation to existing buildings.

11.6. In the few cases where masonry wall construction was seen it appeared to be fairly common practice to provide an air space between the brickwork and the internal plaster by means of battening, rather in the manner common in Scotland. In some towns the external 4 in. of wall was of solid brick with an inner leaf of 4 in. or 6 in. hollow block. The 11-in. cavity brick wall as we know it in this country was quite unusual.

FLOOR INSULATION

11.7. It was noticeable that in some houses with solid ground floor construction where the heating was by means of space heaters there were complaints of cold floors. We are unable to say to what extent this could have been improved by better under floor insulation, or to what extent it was due to lack of any radiant heat. The majority of floors of this kind which we saw were in temporary wartime houses and, therefore, not necessarily of normal construction. In a few cases 2 in. to 3 in. of vermiculite or other lightweight concrete was used below the surface concrete, but we understood that generally speaking the use of special insulation to such floors was unusual. It is interesting to note that one of the advantages of having a heating furnace in the basement is said to be the comfort from the warm ground floor which is thus obtained.

AMOUNT OF INSULATION TO BE USED

11.8. There seemed to be a marked lack of informed opinion on this subject among designers and we were repeatedly told that normal practice was to rely upon figures provided by the various firms specialising in the manufacture or sale of insulating material. Consequently we found it difficult to obtain unbiased evidence on the fuel economy resulting from the use of insulation.

11.9. There is a little test data from research work at Universities which gives information on actual fuel savings resulting from the use of insulation. In one test house at the University of Illinois, Urbana, for example, a fuel economy of 30 per cent. actual as against 38·6 per cent. calculated was obtained. At St. Paul, Minnesota, there have been tests on four houses showing that up to a certain point additional insulation is worth while, but that beyond this the extra saving of fuel becomes proportionately less.

11.10. The value of heat insulation is recognised by the Housing Authorities. For wartime housing there was a requirement that the total heat loss from a house should not exceed 60 B.Th.U. per hour per sq. ft. of floor area, or 80,000 B.Th.U. for the entire house, whichever was the lesser figure, with the interior temperature at 70°F. and the exterior at the design temperature for the locality. The following comment on the effect of this rule was included in an official circular :—

> " During the war period the use of heat resistive materials, such as insulation, weather stripping and storm sash windows was greatly accelerated due to the necessity for conserving metal and fuel. A

limitation of the heat losses of all housing constructed during the war period was included in the War Production Board Critical List and is continued in effect in the revision of 17th October, 1944. The limitation not only accomplished its purpose of conserving metal and fuel but reduced initial costs of equipment, made possible a greater standardisation with fewer sizes, lowered the cost of heating, and improved overall comfort ".

" The generally satisfactory experience with heat resistive materials in both old and new construction indicates the likelihood of a substantial public demand for the inclusion of these items in post-war houses. In some areas public demand may have been stimulated to a degree calculated to effect adversely the marketability of houses in which they are not included ".

11.11. The use of an overall limitation on heat loss such as is provided by the 60 B.Th.U. per hour per sq. ft. of floor area may be of some value and some such figure might therefore be considered for inclusion in our own Codes of Practice but this on its own is apparently insufficient as we understand that there is now under consideration the inclusion of additional requirements covering unit heat losses from " exterior walls ", " ceilings exposed to unheated spaces " and " floors over excavated spaces, garages or porches ". The following comment is also made in the document quoted above: " The heat loss through concrete slabs on the ground requires special consideration . . ."

THE COMFORT VALUE OF INSULATION

11.12. We have mentioned above that the comfort value of insulation was repeatedly referred to. In this connection an interesting memorandum on " A proposed basis for determining minimum requirements for insulation " was prepared in 1940 by Robert K. Thulman of the Federal Housing Administration. In this the author stresses the comfort aspect of insulation and suggests a method of determining the amount of insulation required when the outside design temperature and the desirable inside wall temperatures are known. It is the suggestion that the temperature of the inner wall surface should be the determining factor in arriving at the amount of insulation which is interesting. The author admits that at the time of writing there was insufficient knowledge as to what that wall temperature should be and he advocated that research work should be undertaken to determine it. This is one of a number of factors relating to comfort conditions which has still to be determined.

MATERIALS USED FOR HEAT INSULATION

11.13. A wide variety of materials are in use for heat insulation in houses. These fall into two main types, rigid and non-rigid materials. We were told by more than one person that as a result of keen competition the " rigid " and " non-rigid " manufacturers had developed a kind of advertising warfare in which each side had been so successful in pointing out the drawbacks of the other that the result had been almost to frighten some people from using any kind of insulation at all It is to be hoped that manufacturers in this country will take a more long-sighted view of the situation.

11.14. Materials which were in most common use seemed to be the mineral wool group, a term used to include rock wool, slag wool and glass wool. Shredded wood or bark fibres were widely used in some areas and cotton, paper or cellulose fibres were also seen ; such materials are usually treated to reduce fire risk. Vermiculite was used, mainly on the tops of ceilings or as an aggregate for lightweight building blocks, but cork insulation was not seen in any of the houses we visited. Fibre boards were used as a combination of insulation and lining material and, as mentioned above, an air space was often provided behind a plaster wall finish by battening out from a solid wall. Aluminium foil was recognised as of value and had been used in some cases. Opinions seemed to be that its value would not be likely to be affected by ageing. Insulation of old houses was often carried out by blowing mineral wool into the cavities of frame construction. Occasionally there is trouble from subsequent packing down, but it is said that this should not occur if the work is done properly.

11.15. A number of research laboratories are equipped to carry out thermal transmittance tests and in some cases have obtained results on composite walls, e.g. at Massachusetts Institute of Technology we were told of experiments on the comparative value of air spaces of varying thickness and on the effect of horizontal sub-divisions to a tall thin air cavity. It was stated that sub-divisions increased the heat flow through the cavity in certain circumstances. At Purdue we saw various insulating materials, including two types of glass fibre insulation, one with rather coarse fibres arranged directionally and one with very fine fibres not arranged in any particular way. We also saw at this same laboratory an extremely light-weight block produced by one of the rubber tyre manufacturing companies. In the laboratory at Purdue we saw examples of insulating materials undergoing an accelerated weathering test and were told of results obtained which had led to manufacturers making alterations in their products which had increased their usefulness and life very considerably. At Toronto University there were investigations into fundamental properties of insulating materials which appeared likely to lead to valuable results when applied by manufacturers. In particular, surface resistance and the arrangement of material in fibrous and granular types of insulating materials have been studied.

REDUCTION OF HEAT LOSS THROUGH WINDOWS BY DOUBLE GLAZING

11.16. Under the cold climatic conditions of Canada and a considerable part of the U.S.A., heat loss through windows is of importance for three reasons :—

(*a*) The very cold area of windows can cause a real feeling of discomfort even in a room where air temperatures are well maintained at high level. This is partly due to the direct radiation of heat from one's body to the cold window area and partly to the fact that the cold window causes a downward flow of the air cooled against the surface of the glass with a consequent feeling of cold draughts. The subject of heat loss through windows had not yet been sufficiently well studied, especially in regard to the amount of heat lost by conduction and radiation but existing literature is being reviewed by the American Society of Heating and Ventilating Engineers.

(*b*) The very cold glass surface leads to considerable condensation in spite of the low humidity of the air.

(*c*) The actual heat loss is very considerable if reasonably large windows are used, unless there is careful orientation to the sun together with a use of blinds or curtains at night.

11.17. The use of some form of double glazing has received a fair amount of attention, but so far as we could see is not common practice in small houses except in the coldest areas. Of the places we visited, Montreal was the only one where double glazing of some kind was accepted as a normal thing.

11.18. It was difficult to obtain actual data on fuel savings resulting from the use of double glazing. In tests at Urbana on one house an actual saving of fuel of 15 per cent., as against a calculated saving of 27 per cent., was obtained by using storm sashes. Generally, people were satisfied that where they had fixed double glazing of some kind to an existing house they had reduced fuel consumption by an appreciable amount and had certainly improved comfort conditions.

11.19. There are at present four ways of providing double glazing and examples of each were seen.

(i) Two permanent windows in separate frames. This was most unusual in housing generally and practically non-existent in small houses, although in offices and public buildings it was fairly common.

(ii) Two windows in separate frames provided by the use of a removable storm sash which is fitted for winter only. The common practice is for the storm sash to be fixed externally and top hinged and to be capable of some degree of opening to permit ventilation. In actual fact we doubt whether in most houses the windows are opened at all in cold weather except possibly at night in the bedrooms. The use of storm sashes seems to have increased somewhat as a result of fuel oil rationing, but it is still not common practice in small houses. Quite often the individual house owner will provide them himself where they are not included as part of the original construction. Advertisements for storm sashes were commonly found in the daily and weekly newspapers, so there is presumably a considerable sale to private individuals. Difficulty of storage does not arise where the house has a basement, but otherwise an appreciable amount of accommodation must be provided. We found, especially in Canada, that where houses were rented the landlord did not usually provide storm windows and the reason given was that where they were not their own property tenants would not look after them satisfactorily and breakage was high. The exception to this was in Montreal where special conditions altered the situation. Incidentally the business of putting up and taking down the storm sashes at the beginning and end of the heating season appears to be one of those occasions where the housewife has to use considerable tact and persuasion before she can get the husband to tackle the job—it appears to be a task somewhat comparable with the " venetian blind cleaning ordeal ", which was once such a feature of the English spring-cleaning season.

(iii) In a few private houses we saw double glass set into one frame with the outer glass arranged for removal by the rather laborious method of removing wooden fixing beads. Apparently in a country district such removal for cleaning is necessary about once a year. In an attempt to avoid condensation between the two panes of glass small ventilation holes are made through the frame to outside. Apparently the number and size of such ventilation holes is arrived at by a process of trial and error.

(iv) Lastly there is the use of patent double glass units constructed with an airtight seal. It appears that these are now being accepted as technically satisfactory but that they are at present much too expensive to be used except in rather luxury housing. One architect who had used this type of glazing took the view that although it is at present considered a luxury, it is really an essential to comfortable living, at least in a cold climate, and he suggested that much in the same way that bathrooms and other items had in a comparatively short time developed from the " luxury " to the " essential " class, so too would this form of glazing be found in common use within a short time.

11.20. The only other development in double glazing which we heard of was one suggestion in Canada that to improve comfort in cold weather it would be useful to provide some form of heated window. The scheme which we saw in draft form only was based on a warm air circulation between double windows.

REDUCTION OF HEAT LOSS THROUGH WINDOWS AND DOORS BY PREVENTING AIR INFILTRATION

11.21. The reduction of air infiltration is clearly more important where outside temperatures may be at 0°F. or lower, than in a moderate climate and its value is recognised over a fairly wide area. It is also more important with warm air heating than with high temperature radiant heating. Where double windows, in separate frames, or storm sashes are provided it should be unnecessary to provide an additional check.

11.22. We found that weather strip was fairly commonly, though by no means always, used in small houses where the cost of double glazing of any kind was considered too high. The weather stripping of external doors was particularly common. In the past, weather stripping had usually been a special operation but it is now becoming more usual to find windows supplied complete with weather strip ready fixed and this was said to be appreciably cheaper. The materials used are either copper alloys or zinc. Almost all the examples we saw were of the copper alloy type. Two types are used, either a spring closure or an interlocking closure. An advantage of the interlocking type was said to be freedom from any tendency to cause the door or window to be difficult to open. In one place it was said that the spring type made it difficult for children to open doors.

SUMMARY

11.23. Clearly, heat insulation and the reduction of heat loss by air infiltration require consideration from the point of view of added comfort as well as from the purely economic standpoint. Experience in America shows it has an economic value and experiments in this country should be pushed forward with all speed so that we may carry out insulation on a scientific basis. The probable value of insulation may, of course, change appreciably if standards and methods of heating develop. Presumably a higher standard of heating will increase the value of insulation while higher efficiency of the heating appliance would decrease its economic value.

Chapter 12

CHIMNEYS

GENERAL

12.1. Two factors have led to developments in forms of chimney construction different from ours. These are, first, the considerable number of fires caused through faulty chimneys, and second, the increase in the use of gas fired appliances which resulted in serious deterioration of brick chimneys.

12.2. The risk of fire appears to be greater in some communities than others. It is possible that the attention given in U.S.A. to chimney design and in particular to chimney linings may have been partly due to the high incidence of chimney fires in certain areas.

GLAZED CLAY LININGS

12.3. In many towns it is now common practice to line new brick flues with either glazed clay sewer pipes or, more usually, with glazed clay blocks. The blocks are usually about $\frac{3}{4}$ in. thick and square jointed. They are made in sizes giving flue areas of 24 sq. inches upward and in lengths of up to 24 in. Where these linings are used they are surrounded by 4 in. of brickwork. Where there are two flues of sizes up to 80 sq. in. each they may sometimes be divided only by the two thicknesses of clay block.

12.4. Apart from their value as a precaution against fire it is claimed that these flues withstand the conditions arising from gas fired appliances. They are widely used where there are gas fired units and the claims seemed to be justified although we were unable to find any reason why the cement jointing did not suffer attack as it does in brickwork flues and in one or two cases opinions were given that such attack does sometimes occur.

12.5. It was also interesting to note that it was generally appreciated that the smooth lining resulted in a much better flue draught and in much less deposition of soot in the chimney than in the normal brick flue.

VITREOUS ENAMELLED SHEET IRON FLUES

12.6. Protected metal flues were designed in the first place as linings to go into defective brick flues. Later they were found useful as linings to brick flues into which gas fired appliances were to be connected. They are now being used for new flues and for special types of heating plant such as the chimney furnace described in Chapter 8, but the main sale is for lining defective chimneys to coal fired appliances.

We understand that a number of firms manufacture vitreous enamelled iron flues but there was a very widespread impression that the products of one firm were satisfactory whereas those of some other firm were not so well thought of. Whether this feeling was due merely to better advertising of the one firm we cannot say, but certainly its products were used over a very wide area and they had been tested at the Bureau of Standards. We obtained some details of this particular flue and saw an installation which had been tested at the Fire Underwriters' Laboratories in Chicago.

12.7. The metal flue which we saw was made of what was described as a " special porcelain enamelling iron ". For flues up to 6 in. diameter a 22 U.S. gauge iron is used and for 6 in. to 12 in. diameter a 20 U.S. gauge. The sections are 24 in. long and are socket-jointed with a 2½-in. lap, socket up. Mass production with dies is said to make them self-registering. They may be made in a slightly tapering form to allow for nesting and therefore economical transport.

12.8. The enamel, which is covered by patent, is applied in two coats. At present the only colour available commercially is standard chrome green but other colours have now been found satisfactory in laboratory tests.

12.9. In addition to the single metal flue there are also double types made with insulating material between two concentric pipes. The insulation is of 1-in. thick asbestos composition. With a slow combustion stove giving 500–700°F. flue temperatures it was said that the outside temperature of an insulated flue was about 125°F.

12.10. When placed inside a brick chimney stack the flue is installed either by pushing up sections from the bottom or by dropping down from the roof. Where a double pipe with insulation is used there is no jointing material between sections. Where there is a single pipe the joints are made with a special acid-proof asbestos cement. Near the roof an expansion joint is formed in the flue and above the roof level there may be special cover units designed to resemble the shape of a brick chimney and to form the necessary flashing to roofs of varying pitch.

12.11. Condensation within the flue falls into the stove where this has a vertical outlet or to a drain plug and waste pipe when the stove has a back outlet.

TITANIUM ALLOY-COATED FLUES

12.12. We were told of the manufacture by one firm of titanium alloy-coated steel flues which were said to be satisfactory for gas appliances.

ASBESTOS CEMENT FLUES

12.13. For flues where temperatures will not exceed 550°F. asbestos cement is recognised as satisfactory and apparently proves resistant to the conditions obtaining with gas fired appliances. We were told that there had been a number of failures where this type of flue had been used under conditions giving higher temperatures and that therefore they were considered unsuitable for use with coal or wood fired appliances. We did not see, but were told of, a type of asbestos cement flue known as " integrally waterproofed ", the composition of which included a small amount of asphalt. This was said to have been approved by the city of New York for use on all types of appliance for temperatures not exceeding 1,400°F. It has been tested by the Bureau of Standards.

ALUMINIUM FLUES

12.14. We did not see any aluminium flues but understand that two firms in California have manufactured them for use with gas appliances and that for this purpose they had proved satisfactory.

SPRAY TREATMENT OF EXISTING FLUES

12.15. We were unable to find anyone with any knowledge or experience of a spray treatment of existing flues, but work on this was done in Canada some years ago and the results published.

FLUE CLEANING

12.16. The practice of chimney sweeping, as we know it, does not exist in America. Apparently there are firms which specialise in "chemical cleaning" but the majority of people when questioned said that with lined flues it was very seldom that anything had to be done. Occasionally the tenant would deliberately burn out the chimney.

USE OF ONE FLUE FOR TWO APPLIANCES

12.17. It was quite common practice to run the flue from a gas water heating appliance into the main flue stack. The regulations usually stated that the secondary flue should enter at least 12 in. above the main entry, but we saw some examples of two inlets at the same level.

SUMMARY

12.18. The use of glazed clay linings to brick flues has much to recommend it. Brick flues are considered unsatisfactory for gas fired furnaces for space heating. Vitreous enamelled flues are increasing in use both as new flues and as linings for existing brick chimneys. Provided that a satisfactory enamel is used they appear to give good results and as they might well lead to considerable saving of time and money it is suggested that trial installations should be made and kept under observation.

Chapter 13

RESEARCH WORK, TESTING AND STANDARDISATION

GENERAL

13.1. In Chapter 1 we gave our general impressions of the organisation of research work, testing and standardisation. We feel that it may be of value to workers in this country to have a brief description of the work of institutions in U.S.A. It is not possible for us to describe fully the past or even present work on domestic heating of all the places we visited, but the following notes cover the work which was seen or described to us in the institutions we visited. There are many other organisations, particularly State Universities, carrying out research on domestic heating, but lack of time prevented us from visiting all of them. We collected a considerable quantity of published literature, a list of which is given in Appendix 6.

NATIONAL BUREAU OF STANDARDS, WASHINGTON, D.C.

13.2. *Appliance Testing.*—In the Heat Transfer Section of the Heating and Power Division, testing of appliances, mainly solid fuel and oil, is carried out at the request of Government agencies. Very little is done with gas appliances, which are usually tested by the American Gas Association and only a very small amount of work has been done with electrical appliances. In peace-time a staff of eight tested about six appliances a month. Manufacturers are invited to be present during testing. Reports are issued to the Government agencies concerned.

13.3. At the time of our visit the only tests being carried out were those required in direct connection with wartime housing projects.

Apart from straightforward efficiency tests there is a test house which is weather controlled in which tests are carried out from the point of view of heating and air distribution. There is a plenum chamber beneath the house and a variety of heating methods can be used.

13.4. An insulated calorimeter room has just been completed. It is insulated with 4-in. rock wool so that heat losses through the walls are small and may be allowed for. Heat outputs are determined by measuring the air flow through the room and the inlet and outlet temperature. The quantity of air is measured by an orifice and Pitot tube and the temperature by thermocouples. Air supply and outlet dampers and fans are arranged so that atmospheric pressure can be maintained in the room.

13.5. Test codes are being prepared for bituminous coal fired space heaters and for solid fuel cookers.

13.6. *Insulation Tests.*—*U*-value measurements are carried out in a hot box with a specimen 5 ft. by 8 ft. surrounded by a guard ring, all tests being made with specimens vertical. No work has been done on edge effects in composite panels.

13.7. Some tests were being carried out on heat losses from solid ground floors with particular reference to losses by edge transmission.

13.8. *Tests on filters.*—A considerable amount of work was in progress on filters for warm air heating installations. There was some difficulty in obtaining agreement with industry as to the methods of test which should be adopted.

13.9. *Testing standards.*—The general position regarding standards for testing appliances is given in a paper by Mr. R. S. Dill, of the Bureau of Standards, presented at the American Society of Heating and Ventilating Engineers' Annual Conference, January, 1945. This paper summarises the standards for heating and water heating devices prepared by the National Bureau of Standards, Institute of Cooking and Heating Appliance Manufacturers, Institute of Boiler and Radiator Manufacturers and American Gas Association together with certain proposed standards now being developed by the National Bureau of Standards. Test fuels, stack temperatures, carbon dioxide content of flue gases and thermal efficiencies for the various standards are summarised together with brief descriptions of the tests and any special requirements.

13.10. Standards are prepared by the Trades Standards Division of the Bureau in the following way. A Government Department or manufacturer or any individual or group makes a request for a standard. The person making the request then has to prepare a draft which the Bureau of Standards will circulate to all concerned. If necessary a conference will be called. A Drafting Committee is formed and re-drafts the standard in the light of all comments received. Before the standard is issued there must be an acceptance by 65 per cent. of the industry on a production basis. A list of those subscribing to the standard is appended to the published document, as also is a copy of the statement of acceptance which has to be signed by each subscriber.

13.11. The Trades Standards Division of the Bureau is maintained to facilitate better understanding within the entire trade while the Heat Transfer Section is the technical authority of the Government on heating appliances.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

13.12. The American Society of Heating and Ventilating Engineers has not only carried out research in its own laboratories but has also provided funds for work in Universities. Commercial testing is not undertaken by the Society. Funds for research work are provided by 40 per cent. of the total money received in membership dues, by profits from the bi-annual convention and by contributions from individual concerns.

The investigations include work on winter and summer comfort conditions in relation both to temperature and humidity, barometric dampers, heat loss through windows and the compilation of the vast amount of data given in the A.S.H.V.E. Guide. The work of the Society is not confined merely to the engineering problems of heating, ventilating and air conditioning, but to all its aspects; its membership includes fuel technologists and physiologists as well as heating and ventilating engineers.

A large experimental programme is envisaged and will proceed as soon as staff can be made available.

BUREAU OF MINES, PITTSBURG

13.13. Very little work of direct interest to us was being done at the Bureau of Mines as all the Government work on heating appliances is carried out by the Bureau of Standards. The Bureau of Mines acts in an advisory capacity on smoke abatement and has prepared model smoke laws. Work has been done on smoke measurement, chemical fuel "savers" and soot removers. (See Appendix 1 for details of apparatus on smoke measurement.)

BITUMINOUS COAL RESEARCH INC., AND BATELLE MEMORIAL INSTITUTE, COLUMBUS

13.14. Bituminous Coal Research is an industrial research organisation sponsored by the bituminous coal industry. Research is carried out at the Batelle Memorial Institute, Columbus.

13.15. *Group heating*.—A study has been made of block heating, i.e. heating one or more blocks of houses from a single boiler house with no mains crossing streets. Calculations have been made for a scheme of 30 houses. A progress report will be completed very soon.

13.16. *Smokeless furnace*.—Work was being carried out at the Batelle Memorial Institute on the development of a smokeless solid fuel heater. This work was financed through Bituminous Coal Research by a limited group of manufacturers and was confidential, so we were unable to obtain details. We saw the heater under test and were told that very good results were being obtained.

13.17. *Automatic Stoker*.—Some work was being done on a small fully-automatic stoker with a rotary grate which ensures satisfactory de-ashing. It is designed to burn without clinker but is provided with teeth on the grate to break any clinkers which may be formed. Ash removal is by a worm screw.

13.18. *Calorimeter room*.—The construction of a calorimeter room for the direct measurement of thermal efficiency of heating appliances is just being completed. It is about 12 ft. by 12 ft. by 8 ft. high and is made of "celotex" on an internal wood frame. The floor is heavily insulated. Heat transmission through the walls is measured by means of thermocouples on the inner and outer wall surfaces and heat transmission to the ventilating air is measured by a venturi, Pitot tube and thermocouples in both inlet and outlet ducts. In order to eliminate air leakage the air is maintained at atmospheric pressure in the room by means of manually controlled dampers. As far as we are aware this is the only calorimeter room of its kind in the U.S.A.; it is more elaborate than that at the Bureau of Standards.

13.19. *Reports*.—Three kinds of report are issued by the Batelle Institute: (*a*) confidential reports on research programmes for individual members;

(*b*) reports to Bituminous Coal Research; and (*c*) published editions of reports to Bituminous Coal Research. Apparently it would be possible for British manufacturers to receive the (*b*) class of report either by individual or group membership of the Institute and consideration might be given to the advantage of such an arrangement.

ANTHRACITE INDUSTRIES INC., PRIMOS

13.20. This is the research organisation of the anthracite producing industry. Until 1942 the laboratories were engaged only on testing work but since then fundamental and applied research has been carried on. Finance is solely from the anthracite industry, but very close contact is maintained with appliance manufacturers.

13.21. *Methods of combustion.*—Considerable fundamental research has been carried out on heat transfer from beds of anthracite burning in cylinders of various sizes. Combustion taking place in a glass tube under various conditions was examined and also recorded by means of a series of motion pictures. This work led to the development of the new type of tube heater described in Chapter 8 and almost all available resources appeared to be concentrated on this.

13.22. *Appliance testing.*—Appliance testing is carried out at the cost of appliance manufacturers. The purpose of the tests may be to assist the manufacturer with engineering suggestions or to determine if the equipment is eligible for the Laboratory's seal of approval. The manufacturer may be present as an observer during the testing of any of his appliances. If an appliance does not pass the standard the manufacturer is given an opportunity to improve it and submit for re-testing. A report of the final test is issued to the manufacturer and becomes his property. He can publish it in full but partial publication is permitted only with the approval of the Laboratory. The Anthracite Ind. Inc. publish a list of all approved appliances. In addition to carrying out laboratory tests full-time officials are employed on field investigations on the performance of anthracite-burning appliances to investigate complaints which are reported to them by local distributors. Field surveys are carried out as soon as possible after a new type of appliance has been placed on the market.

THE AMERICAN GAS ASSOCIATION LABORATORIES, CLEVELAND

13.23. Owing to a recent very serious explosion and fire the work of the American Gas Association Laboratories is at present very restricted. In the past the majority of the work has been on testing, but research is carried out both on appliances and on testing. One piece of research planned for the near future is on flues.

13.24. *Testing of appliances.*—The American Gas Association tests cover not only U.S.A. but also Canada and to some extent South America. About 95 per cent. of all gas equipment in U.S.A. is said to pass the A.G.A.

tests, and there are 221 cities which have ordinances requiring that all gas appliances sold, installed or used shall conform to A.G.A. standards. The plant of all manufacturers of approved appliances is inspected regularly but there are no field tests on appliances except in case of trouble, but field reports are received from gas public utilities.

13.25. About $245,000 was spent annually on testing before the war and about $150,000 on inspection. The list of approved appliances contains about 35,000 appliances.

Appliances have to pass all the tests laid down in the specification and if they fail to conform to any single test details of the failure are given to the manufacturer who then has to make the necessary alterations. Detailed results of those tests to which the appliance conforms are not furnished to the manufacturer. By this method no credit is given to an appliance which is far better than that demanded by the Association as appliances fall into two categories only, " pass " or " fail ", and there is no graduation on merit. When an appliance passes all the tests it is awarded the seal of approval.

13.26. Work is being done on a 100 per cent. primary air burner in which the whole of the air needed for combustion is supplied as primary air. Increased efficiency is claimed. Some work is also being done on neat flame combustion.

13.27. Other work includes research on kitchen ventilation.

UNIVERSITY OF ILLINOIS, URBANA

13.28. A long programme of research work has been in progress over many years in the engineering laboratory and in two experimental houses. There are two main programmes, one sponsored by the Institute of Boiler and Radiator Manufacturers and the other by the National Warm Air Heating and Air Conditioning Association. Each of these bodies has sponsored the building of an experimental house. A considerable amount of data on heating by warm air furnaces and hot water and steam systems has been accumulated and is being constantly increased. It is summarised in two standard works " Gravity Warm Air Heating—Digest of Research, Engineering Experiment Station, University of Illinois ", and " Winter Air Conditioning—Forced Warm Air Heating " by S. Konzo.

13.29. *Warm air heating.*—The work includes measurement of furnace efficiency and performance, fuels and combustion, duct design and performance, register design and positioning, air flow and temperature distribution in rooms, humidification and dehumidification, correlation of laboratory and residence tests, air re-circulation and development of testing codes. The work here more than anywhere else emphasises the importance of proper design of furnace and ducting for warm air systems. The ease with which an unsatisfactory system can be installed is recognised as a potential danger. If any developments of warm air heating are contemplated in Britain it is essential that a careful study be made of the findings of the workers at Urbana otherwise unsatisfactory systems may result.

13.30. *Skirting panel heating.*—At the present time work is being carried on in the Institute of Boiler and Radiator Manufacturers' house on skirting panel heating by gravity warm water circulation. For most rooms it is apparently sufficient to have a heated skirting along one wall, but for very cold rooms it may be necessary to have two wall lengths heated.

13.31. *Smokeless furnace.*—Work on warm air heating was in progress in the National Warm Air Heating and Air Conditioning Association house but this was not seen in detail. Work was going on in this house and also in the University laboratories on the " Fellowes " furnace. This is a smokeless down-draught coking furnace, developed by Professor J. R. Fellowes. It is a hand-fired warm air furnace suitable for domestic use; practically no smoke is given off even when high volatile bituminous coal is used; no special skill is required in its operation. Fig. 16 (p.89) is a sectional drawing of the furnace showing the conditions immediately after firing. Combustion air enters the furnace through three ports; primary air through a port in the ashpit door; coking chamber air through a port in the charging door and secondary air through a port above the charging door, then through passages in which it is pre-heated and finally discharged immediately above the fuel when it burns the volatile matter from the raw coal and any carbon monoxide from the coke bed. It is intended that the three ports should be adjusted in the factory or by the dealer for the type or types of fuel most likely to be used. In experimental work one adjustment has been found to be satisfactory for all types of bituminous coal. The rate of combustion is controlled by a damper in the flue pipe. Tests carried out at high and low rates of combustion and under banked conditions show a considerable reduction in smoke, a more uniform output, and considerably higher CO_2 readings than with a conventional hand-fired furnace. The principle of this furnace is applicable to all types of heating equipment such as boilers, heating stoves, and cookers as well as warm air furnaces. The incentive for this research into methods of obtaining smokeless combustion of coal was apparently due to the progress towards anti-smoke laws in various cities and in particular to the laws already operating in St. Louis.

13.32. In both houses detailed measurements of air temperature and air movement are taken in all rooms.

13.33. The laboratories contain all the necessary equipment for developing and standardising new measuring apparatus and also a weather controlled room in which detailed measurements can be made under any steady desired conditions.

J. B. PIERCE FOUNDATION, NEW YORK & NEW HAVEN

13.34. Work of the J. B. Pierce Foundation is supported partly by the original foundation and partly by industrial sponsorship. We visited the laboratories at New Haven where at the laboratory of hygiene basic work on physiology is being carried on, in particular on heat loss from the body.

13.35. *Radiant heating.*—Other work included a study of heating by radiant lamps, intermittent heating being used. The great problem seems to be to find a suitable material for wall covering which has a high reflection coefficient for heat radiation from low temperature sources. At present the only suitable materials appear to be metals. (Some work on the development of other materials is referred to in the note on Purdue University para. 13.43.)

13.36. *Intermittent heating.*—In a controlled weather house consisting of two rooms experiments were being carried out on fuel consumption under intermittent heating in rooms having wall constructions of differing heat capacity. Some results of these experiments have recently been published as a paper in the A.S.H.V.E. Journal.

13.37. *Heat flow through composite walls.*—It was stated that some work had been done on heat flow through composite walls under unstable temperature conditions but that the results had not yet been published.

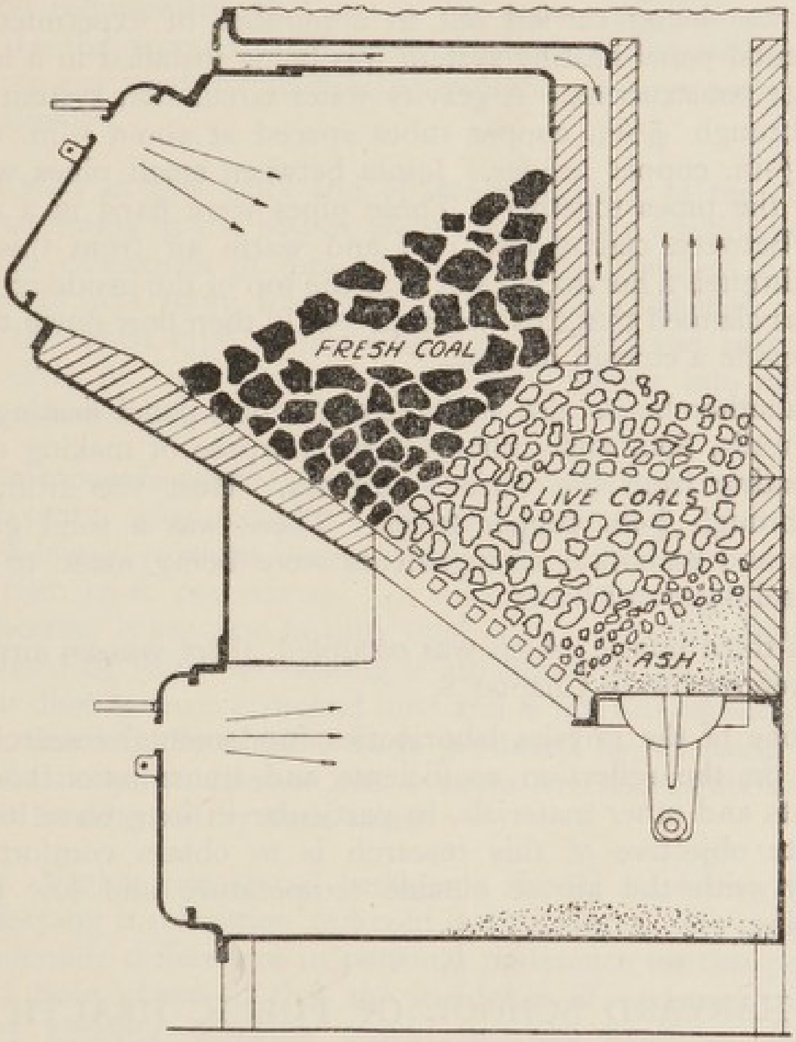

FIG. 16. Section through Downdraught Coking Furnace.

PURDUE MEMORIAL INSTITUTE, LAFAYETTE

13.38. There is a very large engineering school at Purdue. An organisation called "The Purdue Research Foundation" was formed some years ago largely for the purpose of keeping the staff up-to-date on active research work and the research on housing which is at present in progress was said to be for the purpose of improving their own knowledge rather than for advising industry, although reports are issued to firms sponsoring research, and, subject to some control by the Foundation, may be published by the firms.

13.39. *Insulation.*—In the laboratories there was work in progress on the testing of heat insulation materials. Tests were carried out on a 10 sq. ft. test area surrounded by a guard ring separating the hot box and cold box. Tests can be carried out in either horizontal or vertical positions and considerable differences in *U*-value of some panels had been found when tested in the two positions. A larger apparatus accommodated specimens 8 ft. high and 4 ft. wide and it was found that the size of specimen affected the *U*-value. In addition to these tests for *U*-value, insulating materials were tested for durability in an accelerated weathering test. Some interesting results on certain materials such as glass wool had been obtained and had resulted in manufacturers altering their material.

13.40. *Panel heating.*—Some of the most interesting work of the Foundation was being carried out in a number of experimental houses. An experimental panel heating system was being installed in a house which we saw under construction. A gravity water circulation system distributed hot water through $\frac{3}{16}$-in. copper tubes spaced at about 6-in. centres and fed from a $\frac{3}{4}$-in. copper header. Joints between small pipes were formed by sweating the pipes together. These pipes were fixed in a space about 9 in. deep between ceiling and roof and warm air from this space was distributed through a horizontal slot near the top of the inside of the external walls. It was claimed that this warm air would then flow down the wall face and thus provide a curtain of heat.

13.41. In another house also under construction panel heating was being installed in walls, floor and ceiling for the purpose of making comparisons in panel heating from the various surfaces. Heat was from hot water circulated through $\frac{1}{2}$-in. copper tubes. There was a solid ground floor construction and elaborate arrangements were being made to study heat losses from solid ground floors.

13.42. In a third house, which was occupied, there was an airplane heater of the type referred to in Chapter 8.

13.43. In one of the physics laboratories fundamental research work was being done on the reflection coefficients and transmission coefficients of various paints and other materials, in particular in long wave length bands. The ultimate objective of this research is to obtain comfort conditions economically with the air at outside temperature and low temperature radiant heating.

HARVARD SCHOOL OF PUBLIC HEALTH

13.44. *Ventilation and comfort.*—Over a period of many years Dr. Yaglou, a physicist, has been engaged on a study of the effect of environmental conditions on health and comfort. At the risk of giving isolated scraps of information out of their context we record some points which struck us as of particular interest.

13.45. A considerable amount of experimental work had been done on comfort conditions in sealed rooms and in rooms with different rates of ventilation. The general conclusions were that a useful criterion for the minimum ventilation requirements is determined by the effect of body odour concentration, the ventilation required to reduce air-borne germs to a safe concentration in crowded rooms is excessively high and could not be obtained in practice. The ventilation required to maintain a sufficiently high concentration of oxygen is extremely low and with such low ventilation body odour becomes extremely objectionable. Dr. Yaglou has therefore taken as a standard for minimum ventilation that at which the effect of body odour is negligible for those entering the room from clean air. His figure of 10 to 15 cu. ft. per minute per person, which is often quoted, is based on this criterion, but is intended to apply to public buildings where there is a high concentration of human bodies. In an ordinary dwelling of fairly tight construction, Dr. Yaglou considered that condensation would occur before body odour concentration became objectionable and that for houses a ventilation requirement of 5 cu. ft. per person per minute from outside is ample. In the average small house there should be sufficient leakage of air to obviate any need for deliberate ventilation, except perhaps in kitchens and bathrooms.

13.46. In view of this work and of our experience of the absence of any feeling of stuffiness in the houses we visited further consideration might be given to the economies in fuel which could be obtained if ventilation in British houses was more like American practice although, as mentioned elsewhere, the open type of planning may be to some extent responsible for the feeling of freshness and would need taking into consideration in comparing the standards in the two countries.

13.47. Some people are very sensitive to smells of scorched dust, especially during relaxation after activity. Warm air heating does circulate dust through the house, particles being raised from the floor by an air movement of greater than 50 ft. per minute. In spite of this there is no evidence that warm air heating is any less healthy than other methods. The sensation of dryness caused by warm air heating is attributed to the release of ammonia and sulphur dioxide from scorched dust and is not due essentially to the low humidity. Similar effects have been produced by releasing quantities of ammonia and sulphur dioxide into a room in concentrations so low that they cannot be detected by their smell.

13.48. Dr. Yaglou considered bedrooms should be warmed because the object of sleeping is relaxation and cold is a stimulant. He agreed that there were considerable differences in personal preference on this point, but said that it had been observed that the incidence of common colds could be reduced by keeping windows closed in cold weather. (It should be remembered that " cold weather " in U.S.A. means something a great deal colder than normal winter conditions in Britain.)

13.49. Owing to extremely low outdoor temperature in America inside wall temperatures may be from 3–15 degrees lower than the air temperature, consequently for equivalent comfort a higher air temperature is needed in U.S.A. than in Britain.

13.50. Although the open fire produces a sensation of cheerfulness it is physiologically bad because it produces unequal heating of the body.

13.51. There does not appear to be any especial merit to low temperature heating except that in such systems it may be possible to obtain better temperature distribution throughout the room. A disadvantage is that with radiant heating a person is more sensitive to draughts. For floor heating a surface temperature of up to 85°F. should be satisfactory, but Dr. Yaglou had no direct experience. Some people say that ceiling heating is uncomfortable but no unbiassed experiments have been carried out.

13.52. Dr. Yaglou said that in experimental rooms it had been found that with radiant heating people were quite comfortable with an air temperature of 58°F., but it was necessary to heat the walls and cool the air at the same time, thus wasting fuel. In British schools it had been shown that children show greater mental alertness with a temperature of 65–68° F. than with a temperature of 70°F.

MASSACHUSETTS INSTITUTE OF TECHNOLOGY, BOSTON

13.53. A considerable variety of work was done in the various departments of the Massachusetts Institute of Technology.

13.54. *Air conditioning and filters.*—Work on air conditioning was being done although full air conditioning is seldom installed in houses. Work has been carried out on various types of filter, and also on air sterilisation by ultra violet light.

13.55. *Insulation.*—Tests have been made on materials and composite panels, particular attention has been given to foil insulation and some tests have been done on the effect of dividing air cavities horizontally.

13.56. *Water heaters.*—A considerable amount of work has been done for the American Gas Association on gas water heaters in showing the difference between thermal efficiency determined by constant flow and operating efficiency determined by using a pre-determined schedule of water drawn off.

13.57. *Solar heating.*—An experimental house is heated entirely by sun heat throughout the year. Heat storage is obtained by a large tank in the basement and the method of utilisation of the sun heat is by exposing water pipe coils on the roof. Although the project is admittedly economically impracticable in the Boston climate it is providing interesting information which should be of value elsewhere. It is proposed to extend the studies to include solar heating by large windows with a southerly aspect. It is interesting to note that from the work done it was felt that sufficient information had been obtained to enable an opinion to be expressed that solar heating of domestic hot water might well be a practicable proposition in a climate such as that of the southern part of New York State.

ILLINOIS INSTITUTE OF TECHNOLOGY, CHICAGO

13.58. At the Illinois Institute of Technology is the Institute of Gas Technology and also the Armour Research Foundation.

13.59. The Institute of Gas Technology was established at the instigation of the American Gas Association just before U.S.A. entered the war, consequently its development has been hampered.

Work is at present being carried out on a triple purpose kitchen unit in which the cooker, space heater and water heater are incorporated in a single compact unit.

THE MELLON INSTITUTE, PITTSBURG

13.60. At the Mellon Institute there have been a number of Fellows working from time to time on problems related to building. Frequently these are sponsored by manufacturers. There has been a considerable amount of work done on heat insulation materials and the insulation of buildings and heating equipment. At the present time work is in progress on asbestos fibre and magnesia insulation and on asbestos cement ducts.

FIRE UNDERWRITERS' LABORATORIES, CHICAGO

13.61. The Underwriters' Laboratories examine and test appliances for fire risk and to some extent for other qualities. At present there is a working arrangement that gas appliances are not tested here but by the American Gas Association. Test standards are set up by manufacturers' associations and the Underwriters' Laboratories publish standards of test. The Underwriters' Laboratories do not inspect installed appliances.

A number of small oil furnaces and space heaters and various types of domestic boilers were under test. Experiments were being conducted on an enamelled sheet metal flue (see Chapter 12 for discussion of flues).

ELECTRICAL TESTING LABORATORIES INC., NEW YORK

13.62. Electrical Testing Laboratories Inc. is now a company owned by the employees although it was originally formed and operated by the Public Utilities Undertakings.

13.63. A wide variety of testing work is carried out and arrangements are made for inspectors to visit manufacturing plants. Various types of electrical apparatus are tested and there is a close liaison with the American Standards Associations.

13.64. In addition to normal testing work some development work is done for manufacturing firms and there is also an arrangement whereby small rooms with laboratory facilities can be hired by private individuals.

MESSRS. SEARS ROEBUCK CO., CHICAGO

13.65. Messrs. Sears Roebuck are a large trading concern selling in their own multiple stores and also very largely through a mail order business. They have very considerable laboratory facilities for testing to ensure that anything sold by them conforms to the claims they make in advertisements.

13.66. Apparatus under test included cooking appliances, deep freeze units, space heaters, water heaters, and forced warm air furnaces. Tests included efficiency, fire risk, durability, fuel consumption and smoke emission. All testing work is done at the request of the firm's buyers who maintain close contact with manufacturing firms.

13.67. We were very impressed with the work being done as it seemed to be very adequate for its particular purpose.

SUMMARY ON APPLIANCE STANDARDS AND TESTING

13.68. The position regarding testing and the preparation of standards appears to be as follows.

Gas appliances are tested and standards sponsored by the American Gas Association, these cover fire risk as well as performance. These standards are submitted to the American Standards Association for approval.

13.69. Electrical appliance testing is done by the Electrical Testing Laboratories Inc., who, together with the Edison Electric Institute, prepare standards.

13.70. There seems to be no central trade testing organisation for bituminous coal appliances. Standards for appliances have been drawn up for heating boilers and furnaces by the Institute of Boiler and Radiator manufacturers and by the Bureau of Standards, which is also preparing a standard for solid fuel burning cookers.

13.71. Anthracite coal appliances are tested by the Anthracite Industries Inc. to their own specifications and to those of the Bureau of Standards and of the Institute of Boiler and Radiator Manufacturers, and lists of approved appliances are published.

13.72. The testing of oil fuel appliances has not been developed, but some testing is done by the Underwriters' Laboratories Inc. and there are some specifications drawn up by the Bureau of Standards.

13.73. In addition, tests are carried out at the Bureau of Standards at the request of Government Departments and standards for appliances are prepared at the request of manufacturers and others. Such standards may later be accepted by the American Standards Association.

Chapter 14

SUMMARY

SPACE HEATING REQUIREMENTS, VENTILATION AND COMFORT

14.1. We returned from our tour with two major impressions. One was of the great attention given in America to domestic heating problems and their great willingness to share their experience with ours. The other was of the divergences between heating practice in America and Britain, which in the main were that heating of the entire house for 24 hours a day is taken for granted in America; that high temperature radiant heating either by open fire or other means is practically never used on low income group housing; and that ventilation by the introduction of fresh air from outside the house is very much less. In a measure doubtless these divergences are the natural and inevitable consequence of the different climatic conditions in the two countries, but it may be taken as certain that there are lessons to be learnt from the more intensive study of the heating of dwellings which have necessarily had to be made in the severe conditions of America which would find useful application in this country. In the belief that it was the intention that any ideas that emerged from our tour should be followed up in this country by investigation and trial, and in the confidence that the fullest possible co-operation would be accorded by the American authorities, we record in this chapter not only a summary of our conclusions, but also points that seem to merit consideration for action in one direction or another.

14.2. Full house heating appears to have been achieved with comparatively low fuel consumption in America. In this country general ideas seem to stop short at providing a certain amount of "background" heating plus topping-up the room as required by high temperature radiant heat from a separate appliance. This is largely as a result of a desire for economy. American experience suggests that this should be considered as an interim expedient only.

14.3. It has been noted that in America ventilation by the introduction of fresh air from outside the house is very much less than here. If, in fact, American standards are adequate, their adoption in this country would lead to considerable economies. This points clearly to the need for investigation.

14.4. In America there is a very strong desire to provide comfort and convenience. Presumably this may be taken as a logical corollary of the fact that they feel they have achieved economical heating, so they look at increased comfort and convenience as being the next point for development. It is obviously very much a point to be kept in mind in this country.

HOUSE DESIGN IN RELATION TO HEATING

14.5. The modern house in America is more open in its planning than the pre-war British house. There is clearly very close relationship between the type of house plan and the method of heating and it is important that this relationship should be kept in mind. The open plan might well be one of the reasons why the American standards of ventilation are found to be satisfactory. There is already a tendency towards this type of planning in recent examples of house design in Britain. This encourages the idea that a number of such houses should be built and equipped with the various kinds of heating common in America, and investigated and lived in to gain direct experience in this country.

14.6. The widespread use of non-habitable basements in American houses is noteworthy. These basements provide a considerable amount of useful additional space besides being the most convenient location for the heating appliance. The practice of providing basements has largely disappeared in this country mainly, we believe, on the question of cost—chiefly the cost of excavation. Recent improvements in methods of mechanical excavation suggest that the whole question might well be reconsidered although the situation may be less favourable to basements here than in America where deep foundations are necessary in any case.

TYPES OF WARM AIR HEATING APPARATUS

14.7. (*a*) *Pipeless systems.*—Warm air heating installations are very common. Space heaters and pipeless warm air furnaces are economical in installation and running cost, but do not give entirely satisfactory results, in particular they tend to give uncomfortably high temperature gradients. It seems probable that the type of openable stove or closeable fire now being considered in Britain is likely to give rather better satisfaction for our conditions.

14.8. (*b*) *Ducted systems.*—The ducted warm air systems, either gravity or forced, appear to give satisfactory results. The gravity system has the advantage of not requiring the initial running cost of an electric fan but on the other hand it does require a basement location for the furnace. Although these both give a form of heating which, up to now, has not been used in this country, the fact that they are so widely used in America suggests that they should be investigated in the country through trial installations. It is important to note that good design of these systems is a matter of considerable skill and experience, and that in making any investigations advantage should be taken of the very wide experience which American engineers have of this kind of work. There is every reason to believe that any assistance asked for would be most willingly given.

HOT WATER RADIATORS

14.9. In urban districts there is a considerable experience of heating by hot water radiators. The majority of installations in low income dwellings at the present time are in flats, but the use of this type of heating in individual housing is increasing and it is undoubtedly one of the methods which people would most like to have. Experiments are in progress with new types of radiator, in particular with skirting board types in either cast iron or pressed steel. While it may be that initial costs of heating individual houses in this way may be somewhat high by pre-war standards, it offers such advantages as to suggest that some small house installations should be made, partly with a view to obtaining user reactions to this method of heating applied to small houses and partly in order to endeavour to work out an economical system suitable for production and installation in quantity for houses of similar plan.

LOW TEMPERATURE RADIANT HEATING

14.10. The various methods of low temperature radiant heating described in this Report have certain notable advantages. Considerable developments are taking place in America. Britain is regarded as the home of panel heating. American development suggests that we should follow up our pioneer efforts with this method by further experimental development of the system for application to small houses. Warm air panel heating methods seem particularly worthy of investigation.

14.11. The accepted surface temperature for floors is considerably higher in America than in Britain which suggests that there is here a problem for investigation.

OTHER TYPES OF HEATING INSTALLATIONS AND APPLIANCES

14.12. Many new ideas were being tried in America. As some of these, when fully developed, may prove to be of the utmost importance, close touch should be kept with these developments with a view to details being obtained and experimental models made or imported for trial in this country when the time seems ripe. This seems particularly to apply to the new type of anthracite burner, to the chimney furnace and to the airplane type heaters. A study of the down-draught coking type described in section 13.31 should be well worth while in relation to the reduction of atmospheric pollution in our cities.

DISTRICT HEATING

14.13. Although a study of District Heating was outside our terms of reference we saw a number of examples of terraces or small groups of houses heated from central plants. On the whole we received the impression that such schemes were unlikely to be successful unless they could be almost entirely automatic. Of the few larger schemes we saw, such as a central plant dealing with 6–12 blocks of flats, we gained the impression that they were successful. There appear to be many interesting examples of central plants of moderate size as well as the large District Heating schemes. In some cases very complete records are kept. We consider that a separate first-hand study of American grouped heating and District Heating would be very productive.

THERMOSTATIC CONTROL

14.14. Some form of thermostatic control is used in the majority of American houses which have a system suited to such control. There appears to be no doubt that this is definitely worth while with systems using a continuous burning appliance.

MECHANICAL STOKERS

14.15. In larger houses there is a tendency towards the introduction of mechanical stokers. Apart from their value in labour saving they have the advantage of reducing smoke emission and of allowing the use of low quality coal. It is unlikely that mechanical stokers could be justified for individual small house installations but for larger houses their advantages should not be overlooked.

SMOKE ABATEMENT

14.16. There is a widespread interest in the reduction of atmospheric pollution. Drastic action has been taken by the City of St. Louis with excellent results and many other towns are considering ways and means of obtaining similar improvements. While the detailed regulations adopted by St. Louis authorities may not be directly applicable here their method of approach to the subject is interesting and worth keeping in mind in connection with efforts here to deal with the smoke problem.

HOT WATER

14.17. In all new dwellings there is an adequate system of hot water supply. In some cases, usually in flats, this comes from a central plant. In an appreciable number of new estates where individual houses have their own water heating systems there is an arrangement for an unlimited supply of fuel for water heating purposes in return for a fixed additional charge on the rent. This arrangement seems to have much to commend it and the resultant increase in water usage does not seem to be unreasonable when other savings have been taken into consideration. American experience encourages the idea that the system might be tried out on an experimental basis in British housing estates.

SOLAR WATER HEATING

14.18. Solar water heating is an accepted thing in certain Southern areas of U.S.A., but there appears to be a lack of scientific data on the subject. There may hardly be scope for it in this country but its possibilities might be kept in mind for study for use in some parts of the Commonwealth and the Colonies.

USE OF EXTERNAL METERS

14.19. In many districts of America it is compulsory to fix electricity meters on the outside of houses to facilitate reading by Supply Company officials. The system has obvious attractions. In cases where a prepayment meter is required it should be quite possible to arrange the meter in a wall recess, so that it is read from the outside, but accessible for coin insertion from inside.

CONTROL OF APPLIANCES AND TESTING AND STANDARDS

14.20. Housing authorities in America make considerable use of test results when choosing appliances, and in the field of gas appliances the performance and quality standards of the American Gas Association are widely accepted and enforced. There is no corresponding development in this country. There appear to be three essential steps ; first to establish testing methods ; second to develop standards and third to provide a method of ensuring the use of approved appliances. The experience already available in America should be of considerable value.

RESEARCH WORK

14.21. There is a very large total volume of research work in progress in America. Much of this work is done at Universities and there appeared to be some lack of a central organisation for interchange of information. Still more, it was our impression that the exchange of information between Britain and America was insufficient. More effective arrangements for the exchange of literature would in itself be valuable, but it cannot displace the need, impressed on us during the visit for more frequent personal contacts, both official and non-official.

14.22. In general it seems there is a case for encouraging more research in this country on heating methods rather than on combustion.

HEAT INSULATION

14.23. The value of heat insulation is well recognised by both public and technicians and in the colder districts heat insulation is always used. In climates similar to our own standards of insulation are not at present appreciably higher than those of our own pre-war houses. Double glazing in its various forms is not yet common in the smallest houses except in the very cold districts, but its use is apparently increasing. The weather strip for draught exclusion is fairly common, but by no means universal practice.

14.24. There is a very widespread appreciation of the value of insulation from the point of view of increased comfort, in addition to anything it may do to reduce fuel consumption.

14.25. American experience confirms the increasing emphasis being laid in the country on the importance of adequate thermal insulation in the structure of buildings which require heating.

VAPOUR BARRIERS

14.26. We were not able to make a detailed study of vapour barriers, but it is clear that the need for these is well recognised in the colder districts and that with the increasing tendency towards tighter building construction they are becoming increasingly important. It may be difficult to translate American experience to British conditions, but the subject appears to be one which should be examined in connection with the newer forms of hollow wall construction such as are now being accepted.

CHIMNEYS

14.27. There appear to be considerable advantages in the method of chimney construction now generally adopted wherein the brickwork is lined with glazed tile units. This form of construction may show to particular advantage with the increasing use of slow combustion appliances and merits study from this standpoint. Consideration should be given to the advantages which might be obtained by adopting this as common practice in Britain. Also it would be valuable to erect and keep under observation piped flues of the kinds described in Chapter 12 of this Report.

MANUFACTURE OF BRIQUETTE FUEL

14.28. A considerable amount of fuel in the form of manufactured briquette is used. Briquettes are made in two ways ; first by using low grade material and second by using selected materials to produce special grade fuels. The use of briquettes will help to reduce smoke emission and it is suggested that this is a field that should be explored anew in this country. The extent to which briquettes could help to reduce the smoke emission from domestic premises should be considerable.

STATISTICAL INFORMATION

14.29. In the United States statistical information was available in more complete forms than in this country and also in Canada where the Central Statistical Bureau was of especial value. The advantages of complete statistical information for Government and other purposes are so obvious as to raise the question of providing here statistical services on those problems more comparable with what is available in United States and Canada.

GENERAL

14.30. Our general conclusion is that standards of heating and hot water supply in America are considerably higher than in Britain. In the course of this summary a number of suggestions have been made for trial installations. We have it in mind that, subject to reasonable facilities for access for investigations, advantage should be taken of the post-war building programme for incorporating these installations in houses built for occupation. In that way the overall cost of trial installations, which might otherwise be very considerable, would be very much reduced.

Signed—

C. C. Handisyde.
J. C. Pritchard.
R. H. Rowse.

Appendix 1

MISCELLANEOUS NOTES ON RESEARCH METHODS

GENERAL

A1.1. The general programmes of research in the laboratories which we visited are described in Chapter 13. In this Appendix we record some notes of research items which we found of interest.

ABSTRACTING AND INTELLIGENCE SERVICES

A1.2. There are no comprehensive abstracts of current scientific literature published in the U.S.A. covering the same field as the Fuel Research and Building Science Abstracts of the Fuel and Building Research Stations of the Department of Scientific and Industrial Research. The few American research workers who receive these Abstracts have found them most valuable and speak very highly of them ; many other research workers are anxious to receive them. Some co-operative fuel research organisations would very much like to be able to make arrangements for circulation of copies of Fuel Abstracts to their constituent members.

SOLID FUEL APPLIANCE TESTING

A1.3. We saw solid fuel-burning appliances being tested in a number of laboratories and in each case the appliance was on a weighing machine so that rates of fuel consumption could be determined by direct weighing. Weights were generally taken to ¼ lb. for small appliances and to ½ lb. for large appliances. The connection to the flue was made (*a*) by means of a flexible joint of asbestos cloth wrapped round the short flue attached to the appliance and the main flue at their junction. The movement of the scale platform was said to be so small that it did not cause any inaccuracies. Even if this is so it is possible that some inaccuracies may be caused by thermal expansion of the appliance ; (*b*) by means of a water-sealed joint ; (*c*) by loosely inserting a short flue attached to the appliance into the main flue to which a forced suction is applied.

RADIATION MEASUREMENT

A1.4. Even though radiant sources are rarely used for space heating in the States some laboratories were equipped for making measurements of radiant efficiency. The apparatus consisted of a semi-circular arc of 5 or 6 ft. diameter with 12-junction thermopiles located at normal incidence at equal intervals along its circumference. For gas fire testing a single thermopile is used in turn at equally spaced positions along the semi-circle. Readings are taken either on a manually operated or on a recording potentiometer.

SMOKE MEASUREMENTS

A1.5. The absolute determination of smoke does not seem to have developed to the same extent in U.S.A. as it has done in Britain, but a number of laboratories are equipped for making comparative measurements of smoke emission. A sample of flue gases is continuously drawn through a smoke measuring tube which has a light source at one end supplied from a constant voltage transformer and a barrier layer photo-electric cell at the other end. The photo-electric cell has a resistance in parallel with it and the electromotive force across a part of this resistance is recorded by a 10 millivolt recording potentiometer with a 10-in. scale. The tapping of the resistance is adjusted to give an output of 9·5 millivolts when there is no smoke. It is reported that this apparatus is stable in operation.

CONSTANT FLOW GAS SAMPLERS

A1.6. Most laboratories which we visited use a constant flow gas sampling device similar to that developed at the Fuel Research Station by Captain A. Blackie. In one laboratory we saw an apparatus in which the rate of flow was controlled by means of a mercury seal which varied the exposed area of a porous pot through which the gases passed.

AIR MOVEMENT IN ROOMS

A1.7. The University of Urbana have developed an anemometer for measuring air movement. It consists of a small heated copper sphere with a small thermocouple located at a short distance below it. Differential readings are taken on a potentiometer or millivoltmeter which can be located outside the room. It can be used for air speeds of from 20 ft./min. to 3,000 ft./min.

BLACKENING OF RADIOMETERS

A1.8. Professor Pfund of John Hopkins University has done a considerable amount of work on metallic optically black surfaces, but we did not have an opportunity of discussing this work with him ; neither did we meet any research workers who have had practical experience of these surfaces. Investigations have been made on black paints with the result that there are at least two paints available, having a high absorption coefficient, which are reasonably constant and repeatable and do not greatly depend upon the method of application.

RECORDING POTENTIOMETERS

A1.9. Recording potentiometers are regarded as standard laboratory equipment and most of the laboratories which we visited had a number in use, particularly for routine work. They were of the mechanical type with from one to sixteen lines. Several American firms are making electronic recording potentiometers which have a much higher speed of response, but we did not see any of these.

SOLID FUEL COOKER AND HOT PLATE TESTING

A1.10. The test usually consisted of temperature measurement rather than boiling tests. A standard specification now being prepared will include a hot plate test in which the temperature is determined by the use of temperature indicating crayons.

DETERMINATION OF OVERALL CONDUCTANCE (*U*-VALUE)

A1.11. In most laboratories this determination is made by placing the specimen, with guard ring, vertically between hot and cold boxes maintained at the appropriate temperature. In one laboratory the apparatus can be rotated through 90° so as to determine the conductance of the specimen in a horizontal position, a different value being obtained. Some work has been done on the effect of the area of the specimen on the value obtained. In some laboratories the specimen is placed between hot and cold boxes, but on the hot side it is completely shielded by a hemispherical partition in which an electric heating element is situated. The temperature in the hemisphere is maintained the same as that in the remainder of the hot box by adjusting the electrical input which gives a measure of the heat flow through the specimen. This method gives a somewhat different result which may be due to the effect of the hemisphere on convection currents near the hot side of the specimen and to the fact that in the normal apparatus the temperature of the walls may be slightly different from that of the air.

AN INSTRUMENT FOR MEASURING COMFORT CONDITIONS

A1.12. An apparatus is being developed at the Purdue Memorial Institute for determining comfort conditions. It is based essentially on a measurement of the difference between the radiation and convection components of the heat transfer.

Appendix 2

QUANTITY OF HOT WATER USED UNDER VARYING CONDITIONS OF SUPPLY

GENERAL

A2.1. We have referred in Chapter 9 and elsewhere to the method of hot water supply in some estates by which the tenant is given unlimited hot water for a standard charge. In this Appendix we give figures of actual and estimated water consumptions in a number of cases (*a*) where tenants pay for what they use, and (*b*) where they pay some form of standard charge and receive an unlimited supply.

TABLE 13

Tenants Paying Directly for the Hot Water Used

Case	Location or source	U.S. Gallons per family per day	Notes
1.	General	25	Arch. Forum, April, 1939. Estimate for houses of \$3,000–\$4,000.
2.	Westinghouse Home Tests	47·7	Low income group.
3.	Illinois	Average 30	Range from 4 to 49.
4.	Pennsylvania	32	95-day test on 34 dwellings.
5.	New York	62	81 houses. Gas water heaters. Low income group.
6.	Pyrofax (bottled gas) ..	46·3	6-year test. Results in "Pyrofax", July, 1944.
7.	American Gas Association	50	Generally accepted figure.
8.	Gary Housing Project ..	26 to 47	Two houses.
9.	Medium-sized house ..	30	At 170°F.
10.	Philadelphia	26·2	Low income group. Ten houses. Tests over 130 days. Water at 165°F. Range from 12·5 to 44.
11.	Maine	17·7 to 21·6	77 apartments.
12.	Vermont	45	100 houses purchasing hot water.

A2.2. From these figures it can be seen that in dwellings paying directly for the quantity of hot water used, the usage varies fairly considerably with an average of just under 40 U.S. gallons per family per day, which is equal to 33 Imperial gallons per family per day.

TABLE 14

Tenants Obtaining Unlimited Supplies of Hot Water for a Standard Charge

Case	Location or Source	U.S. Gallons per family per day	Notes
	Low Income Group Housing (U.S.H.A. Statistics over 12 months)		
1.	Atlantic City	57	277 dwellings.
2.	Boston (Mass.)	52	1,016 ,,
3.	Cambridge (Mass.)	54	294 ,,
4.	Camden, N.J.	70	514 ,,
5.	Cincinnatti	57	1,039 ,,
6.	Dallas, Texas	61	181 ,,
7.	Cleveland	35	579 ,,
8.	Chicago	77	462 ,,
9.	Indianapolis	61	748 ,,
10.	Lexington, N.Y.	37	286 ,,
11.	Milwaukee	60	518 ,,
12.	Nashville	39	398 ,,
13.	Nashville	52	314 ,,
14.	New York	69	1,622 ,,
15.	New York	70	574 ,,
16.	Washington, D.C.	52	272 ,,
	Average ..	56·4	For 9,094 dwellings.
	Single Bedroom Flats		
17.	Lakeview Estate, Cleveland ..	58	24 families.
18.	,, ,, ,, ..	44	24 ,,
19.	,, ,, ,, ..	80	18 ,,
20.	,, ,, ,, ..	44	18 ,,
21.	,, ,, ,, ..	55	18 ,,
	Average ..	56	For 102 families.
	Three-Bedroom Flats		
22.	Lakeview Estate, Cleveland ..	80	28 families.
23.	,, ,, ,, ..	78	28 ,,
	Average ..	79	56 families.

A2.3. It will be seen that the consumption for families having unlimited supplies of hot water is also variable, although since all figures are averages for a large number of cases it is not possible to say what is the actual range between individual families. The general consumption rate might be taken as about 60 U.S. gallons per family per day, which is equal to 50 Imperial gallons per family per day.

SUMMARY

A2.4. It may reasonably be concluded from the above figures that by providing unlimited supplies of hot water at a fixed charge the consumption in U.S.A. is increased to about 50 Imperial gallons per family per day as compared with just under 33 Imperial gallons per family per day where the payment is by quantity used. It is clear from this that the provision of an unlimited supply does not lead to greatly increased usage and that in fact the amount consumed where an unlimited supply is available is not so greatly in excess of quantities recently suggested in this country as minimum requirements.

Appendix 3

REFRIGERATORS, WASHING MACHINES AND OTHER APPARATUS

REFRIGERATION

A3.1. In urban areas over half of the houses in U.S.A. are fitted with a refrigerator and there is little doubt that almost all new houses will be fitted with them wherever gas or electricity is available. The majority are electrically operated and they are usually about 6 cu. ft. capacity. Summer weather conditions are such that some form of refrigeration is a necessity and in those houses without a mechanical refrigerator an ice box is nearly always fitted.

A3.2. An interesting development which was taking place immediately before the entry of America into the war was the " Deep Freeze " unit. This is used for long-period storage; fruit and vegetables and other things which are bought cheaply during the plentiful season are stored for winter use. Installations in individual houses of the wealthier people were taking place in appreciable numbers. There are, also, some communal units in towns and villages where individual families can rent space. Although at present the cost of individual units is likely to be too great for their use in low income group houses we found a number of people who thought that there would be a very rapid development after the war. Apparently some companies have already in mind a house-to-house delivery of food prepared ready for immediate storage and some people thought that in future this might possibly develop to the extent that shopping habits would change and some types of small shops become very much less important.

LAUNDRY

A3.3. Home washing was very usual. In a number of estates of low income groups about 75 per cent. of the people owned electric washing machines. In many flats or terraced houses central wash-house arrangements were provided in basements. Occasionally these were common to a number of buildings but rarely at a distance of more than 100 yards from the furthest dwelling as this seemed to be considered about the limit of distance which people were prepared to go. Washing anywhere away from the home was found to raise difficulties for mothers with small children.

A3.4. In the small laundries attached to groups of houses or flats there were often washing machines operated on the coin slot principle available to all tenants, but even where these were provided many tenants had their own machines which were kept in the central laundry.

Washing by boiling was unusual and the " boiler " was virtually unknown.

A3.5. Clothes drying in the small communal laundries was done by various methods, often by high level unit heaters blowing warm air. In private houses the basement with heating furnace in it was found most convenient both as wash-house and for drying. Winter conditions make outdoor drying impossible for considerable periods of the year.

A3.6. Clothes drying cabinets were scarcely ever used in private houses and the airing cupboard as we know it here seemed to be non-existent, presumably because the whole house was warm and dry and therefore any cupboard was suitable for airing.

DISH-WASHING

A3.7. Dish-washing machines were seen only in a few of the large houses. With intelligent and careful use they seemed to give satisfactory service with the exception that glass does not dry with a really pleasant finish and crockery needs a highly glazed finish if really satisfactory results are to be obtained. It appears that hard types of water leave a deposit on the crockery and that this is not entirely overcome by the use of common types of water softeners.

Machines in the past have been very expensive in first cost but we were told of plans to produce a portable type after the war at a cost of about 100 dollars.

A3.8. We discussed the value of dish-washing machines with a few housewives who had experience of using them and the general opinion seemed to be that they became really worth while with a family of five or six people but not for smaller families.

ELECTRIC MIXING MACHINES

A3.9. Quite a number of people of moderate incomes owned electric mixing machines which were used for a variety of purposes such as cake-mixing, potato-mashing, etc. Every owner was highly enthusiastic and said that once having owned such a machine they would not think of being without one as it saved a great deal of time. Good models at present cost 20–30 dollars. We were told of the probable production of a post-war model at less than 10 dollars, but some doubts were expressed as to whether a cheap unit would prove satisfactory. One factor of importance is the need for considerable variation in speed of the mixer to enable a variety of mixtures, say from eggs to Christmas pudding, to be dealt with.

GERMICIDAL LAMPS

A3.10. Although not at present used in domestic buildings and although possibly not suitable for such use we would like to record that we were told something of the work being done on the reduction of infection by the use of ultra-violet radiation.

A3.11. Apparently this treatment is now well recognised and accepted by the medical profession for use in special cases such as hospital operating theatres and some wards. Its use in schools is under serious consideration, but general usage in other buildings where there might be less satisfactory control is not yet acceptable. It is said to be of considerable value as a protection during certain food manufacturing or preparation processes.

A3.12. Some large-scale experiments have been carried out in army camps with valuable results and some trials have been made in schools and more are planned. It appears that there is ample evidence that the use of ultra-violet radiation can be of very great value even if not suitable for use in all types of building. Clearly this treatment is intimately associated with the ventilation of buildings, and if full information of work in U.S.A. is not already available in this country it should be obtained and examined by the appropriate authorities with a view to carrying out experimental work.

SUMMARY

A3.13. The ordinary refrigerator is rapidly approaching the stage of being an "essential" piece of house equipment in U.S.A., but it should be remembered that summer conditions there are appreciably hotter than in England. The use of deep freeze units is likely to increase rapidly and is a development which might be considered here, particularly for farms and country dwellings. Washing-machines are considered almost as essential as refrigerators. Dish-washing machines may increase in number if a satisfactory cheap model can be produced but are hardly likely to prove very important for small families. The possibilities of germicidal lamps in public buildings should receive appropriate consideration.

In the development of mechanical aids to the housewife up to the present time, kitchen equipment has been dealt with in a rather piecemeal manner. Valuable results might be obtained in this country if we could approach the problem in a broader way, possibly by satisfying a number of requirements with a single apparatus.

Appendix 4

RECORD OF PLACES VISITED AND PEOPLE SEEN

Through our close personal contact with many technicians in America, an increased exchange of information and ideas with this country should be possible in the future. We record in this Appendix the names and addresses of many of the people we saw. We have listed only the names of those with whom we had fairly considerable discussion. In addition we met many other people for a short time whose names we were not always able to record.

As it was not always convenient to make an immediate note of all names and addresses there may be some small errors. If this should be the case we apologise in advance to the individuals concerned.

PLACES VISITED AND PEOPLE SEEN

Town	Association or Firm and Address	Name and Title of Individual	Subject
Boston (Mass.) and Cambridge.	Massachusetts Institute of Technology	William W. Wurster, Dean of Architecture.	General.
		Mr. Anderson, Principal, School of Architecture.	General.
		Professor G. B. Wilkes	Insulation and Gas Water Heating.
		Professor Holt	Air Conditioning.
		Dr. Hottel, Professor of Fuel Engineering.	Solar Heating.
		Dr. Telkas, Physicist	Solar Heating.
	Harvard School of Public Health ..	Dr. C. P. Yaglou	Comfort Conditions.
	Harvard School of Architecture ..	Dr. Walter Gropius	General.
	Private Architect, Baker Bridge Road, Lincoln.	Walter Bogner	General.
	97, Chestnut Street, Boston	Kathrine Bauer, Housing Expert ..	General.
	Boston Gas Co., 100, Arlington Street	Mr. McKern	Gas Appliances and Gas and Solid Fuel Combined Appliances.
		Mr. O'Donnell	
	Heatilator Co.	Mr. Kesalli, Local Distributor ..	Heatilator Fires.
		C. A. Todd, Factory Representative ..	
	American Society of Heating and Ventilating Engineers.	National Convention of A.S.H.V.E. ..	General.
Charleston (S.C.) ..	Housing Authority	Edward Clements	General.
	Housing Committee	Dr. J. E. Smith, Chairman	General.
	South Carolina Power Co.	James F. Crist, Vice-President ..	Electrical Appliances.
		J. P. Connolly, Sales Manager ..	Electrical Appliances.
Chicago (Ill.)	N.H.A., 201, North Wells Street ..	William K. Divers, Reg. Repn. ..	General.
		Clemens M. Roark, Asst. Reg. Repn.	
	F.H.A. Reg. Office	William D. Sorgatz, Chief Architect ..	General.
		Albert C. Zirwas, Heating Engineer.	
	F.P.H.A. Reg. Office	Marc. S. Herzog, Elect. Engineer.	General.
	Fire Underwriters' Labs., 207, E. Ohio Street.	John Neale	Testing and Standards for Fire Risk and other matters.

Town	Association or Firm and Address	Name and Title of Individual	Subject
Chicago (Ill.)—contd.	Condensation Eng. Corp., 122, S. Michigan Avenue.	L. P. Brown	Enamelled Flue Pipes.
	Shaw, Ness & Murphy (Architects), 80, East Jackson.	Mr. Shaw	General.
		Mr. Dauber, Consulting Engineer	Group Heating.
	Illinois Institute of Technology and Armour Research Institute.	Mr. Prestini	General.
		Dr. W. E. Wilson.	
	Institute of Gas Technology	Dr. Yellot	Gas Research.
	Messrs. Sears Roebuck, 925, S. Honan Avenue.	Mr. Brooks, Vice-President	Commercial Testing of Appliances.
		P. F. Wischnef.	
		R. C. Cross, Head of Heating Section.	
	Institute of Design	L. Moholy-Nagy, Head of School	Industrial Design.
	Private Architect, 612, N. Michigan Avenue.	George Fred Keck	General, Solar Houses, Double Glass.
Cleveland (Ohio)	Housing Authority	Ernest Bohn	General.
	Housing Authority	Mr. Glaze, Engineer in Charge of Lakeview Terrace Estate.	Data from Lakeview Group Heating.
	A.S.H.V.E. Research Laboratories, 10,700 Euclid Avenue	Cyril Tasker, Director of Research	Heating and Ventilating Research, General.
		Prof. Tuve, Case School of Applied Science.	Heating and Ventilating Research, General.
		Mr. Parmelee	Heating and Ventilating Research, General.
	Am. Gas Assocn. Laboratories, 10,700, Euclid Avenue (temp. address).	R. M. Connor, Director	Gas Research.
		Mr. Knapp, Chief Engineer.	
		F. E. Vandeveer.	
		Mr. Flint.	
		M. Zare.	
	Bryant Heater Co., 17,825, St. Clair Avenue.	Keith Davies	Stoves and Stokers.
	Private Consultant and Inventor	James G. Miles	Heating Appliances.
	Porcelain Steel Inc., 13,304, Detroit Avenue.	Mr. Fortis	Chimney Type Heater.
	Private Architect	R. H. Cutting (also Secretary to local A.S.H.V.E.).	General.

Columbus (Ohio)	Bituminous Coal Research Inc. & Batelle Memorial Inst., 505, Kings Avenue.	Mr. Landry	Coal Research and Apparatus.
Detroit (Mich.)	Federal Housing Administration, Penobscot Building.	Victor C. Adler, Regional Architect	General and Warm Air Panel Heating and Chimney Furnaces.
		Mr. Clem, Housing Inspector	General and Warm Air Panel Heating and Chimney Furnaces.
	Timken-Detroit Axle Co.	Robert C. Champlin	Heating Appliances.
	Detroit Lubricator Co., Trumball Av.	P. S. Russell	Chimney Furnaces.
Lafayette (Indiana)	Purdue Memorial Institute.	Dr. Meikle, Research Director	
	Purdue University.	Carl F. Boester, Executive and Senior Research, Fellow Housing Res. Division.	
		Prof. W. T. Miller, H. & V. School of Mech. Eng.	
		Juliens Reither, Architect.	
		C. R. Deverall, Heating Engineer.	
		Dr. Karl W. Meissner, Physicist.	
Montreal	J. L. Price, Ltd., Contractors, 680, Sherbrooke Street, W.	J. L. Price	General.
	McGill School of Architecture	John Bland, Principal	General.
New Haven (Conn.)	Yale University	Professor Winslow (also seen in connection with J. B. Pierce Foundation).	Comfort Conditions, Radiant Heating.
		Professor Seeley, Mech. Engr.	Heating Appliances.
		Mr. Pettit, Chairman, Local Housing Authority.	General.
New Kensington (Pa.)	Aluminum Terrace Housing Estate	Ralph J. Grinder, Estate Official	Warm Air Heating.
New York	Anthracite Industries Inc., 101, Park Avenue.	J. D. Jilson	Organisation of Anthracite Industry, Appliances.
		Mr. Denk, in charge of Anthracite Ind. Section of Architects' Sample Corp.	
	Good Housekeeping Inst., 57th Street and 8th Avenue.	Mr. Adler	General Appliances.
	Architectural Forum, 19, West 44th Street.	Mr. Myers, Editor	General.
		Henry Wright.	
	Architects' Sample Corp., 101, Park Avenue.	—	Appliances.

Town	Association or Firm and Address	Name and Title of Individual	Subject
New York—contd.	Architectural Record, 118, West 40th Street.	Kenneth Stowell, Editor Douglas Haskell.	General.
	Task Magazine, 101, Park Avenue	Herman H. Field	General.
	Sweets Catalogues, 119, West 40th St.	Lonberg Holme	General.
	American Standards Association, 70, East 45th Street.	Dr. Agnew Mr. McNair.	Standards.
	American Gas Association, 420, Lexington Avenue.	Major Alexander Forward (Director) A. T. King (Manufactured Gas). G. H. Smith (Natural Gas). Mr. Caine, Head of Statistical Section. Miss McQueen, Domestic Services Dept. C. Geo. Siegler, Utilisation Engineer.	Gas Statistics, etc.
	American Society of Heating and Ventilating Engineers.	Mr. Hutchinson, Secretary	General.
	Electrical Testing Labs. Inc., 2, East End Avenue and 79th Street.	Preston Miller, President F. Malcolm Farmer, Engr. Vice-Pres. Gordon Thompson, Chief Engineer. H. H. Miller, Commercial Engineer.	Testing and Standards of Electrical Appliances
	J. B. Pierce Foundation, 40, West 40th Street.	Mr. Vermilya	General.
	Robert Davidson & Associated, Madison Avenue.	Kathrine Palmer (Assistant to Robert Davidson).	General.
	Westinghouse Elec. Co., 40, Wall Street	C. W. Flood Wm. E. Smith. Mr. Meisner.	Germicidal Lamps.
Norfolk (Va.)	Allied Heating Products Inc., 2,706, Colley Avenue.	W. H. Webster, Heating Contractor	General.
Ottawa (Ont.)	National Research Council	Dr. R. W. Boyle, Chief Physicist J. D. Babbitt.	General.
	Bureau of Statistics	Mr. Cudmore, Dominion Statistician Mr. Greenway. Mr. Rosen.	Statistical Information.

Ottawa (Ont.)—contd.	Bureau of Statistics	Mr. Wrong. Mr. McLeod.	
	Private Architect	H. Carver	General.
	Ministry of Finance	Dr. Clarke, Deputy Minister. Mr. Sharpe. Mr. McCrae. Mr. Dudley, Deputy Director National Housing Administration.	General.
	Reconstruction Department	Mr. Mackintosh	General.
	Department of Munition Supplies	Mr. Neat, Deputy Director of Fuel Department.	
	Wartime Prices Trades Board	Mr. Foreman, Co-ordinator of Capital Equipment and Durable Goods.	Appliance Distribution.
	Fuel Research Station	Dr. B. F. Haanel, Director R. E. Gilmore, Superintendent. Mr. Burraugh. Mr. Baltzer.	Fuel Research and Testing of Appliances.
Pittsburg (Pa.)	National Housing Agency, Arrott Bldgs., 401, Wood Street.	John C. R. Kelly	General.
	Pittsburg Housing Authority	George Evans, Chairman Clarence C. Klein, Administrator. Ralph Harkins, Director of Management. Harry Ingram, Supt. of Construction. S. I. Hidinger, Supt. of Maintenance. Wm. Schlenke, Planner. J. C. Linehan, Project Co-ordinator. Saul Shapiro, Executive Assistant.	General.
	Mellon Institute, 4,400, 5th Avenue	Russell H. Heilman, Research Fellow	Insulation.
	Bureau of Mines	Mr. Greenwald W. T. Reid.	Fuel Research.
	Bituminous Coal Research Inc., 719, Oliver Bridge.	Dr. Harold J. Rose	Research.
	A. M. Byers Co., Clark Building	Chas. A. Hawk Mr. Cushing.	Panel Heating.
	Ruud Mfrg. Co., 2,934, Smallman St.	G. M. Rohde	Gas Water Heaters, Hot Water Consumption.

Town	Association or Firm and Address	Name and Title of Individual	Subject
Portland (Oregon) ..	Div. of Industrial Resources and Development, U.S. Dept. of Interior, Bonneville Power Administration.	F. O. Billings	Electrical Heating and other Apparatus, Off-peak Loading.
	Bonneville Power Administration ..	Emil John	
		Mr. Cochran.	
		Mr. Rowan.	
		Mr. Kelsey, Electricity Manager, Cawlitz Cy. District.	
	N.H.A. Reg. Office	Mr. Cuthbert	
Primos (Pa.)	Anthracite Industries Inc. (Labs.) ..	Dr. Raymond C. Johnson, Director of Research.	Anthracite Research.
		Dr. Engle.	
St. Louis (Miss.) ..	Local Authority	Col. H. D. McBride, Director of Public Safety.	Atmospheric Pollution.
		Mr. Carter, Smoke Commissioner.	
		Mr. Cassidy, Inspector.	
	Stok-A-Fire Co.	Roy A. Graham	Mechanical Stokers.
	American Stove Co., 4,931, Doggett Av.	Arthur Stockstrom, Director of Research	Gas Appliances.
		Mr. Broadbeck, Head of Research Dept.	
	Charter Oaks Stove & Range Co., Antelope Street.	C. L. Sears, General Manager ..	Solid Fuel Heaters.
		C. G. Buder, Asst. General Manager.	
		Mr. Baker, Sales Manager.	
Seattle (Washington) ..	N.H.A. Regional Office, Vance Building	Geo. W. Copler	General.
	F.H.A. Regional Office	Mr. Albertson	General.
	Chimney Furnace Eng. Co. (address now is : 1,510 W.6, Columbus, Ohio).	M. L. Mueller	Chimney Furnaces.
		Mr. Mueller (Jnr.).	
	Pacific Coast Coal Co., 4,521, Leary Way	Mr. Kerrihard, Manager Heating Divn.	Chimney Furnaces.
		L. D. Waters, Allied Home Appliances, Takoma, Washington.	
Toronto (Ont.) ..	Toronto University	Prof. Eric Arthur, Head of School of Arch.	General.
		Prof. E. A. Allcut, Prof. Mech. Engr. ..	Testing, Insulation.
		F. W. Chambers, Heating Consultant ..	General.

Toronto (Ont.)—contd.	Toronto University	H. H. Angus, Heating Consultant	General.
		Mr. Adamson, Architect	General.
	Government Administrator of Plumbing and Heating, 86, Adelaide Street.	G. M. Molesworth	General.
	Consumer Gas Co., Adelaide Street	A. J. Strain, Sales Manager	Gas Appliances.
	Gurney Foundry Co.	Holt Gurney, Director	Appliances.
		A. W. Givan.	
		Mr. Mitchell.	
		Mr. Davies.	
	General Elect. Canada	Mr. Packham, Sales Manager	Electrical Appliances.
	Ontario Hydro-Elect. Commission	Wills MacLachlan	Use of Electricity.
		Mr. McHenry.	
		Mr. W. R. Harmer.	
		W. P. Dobson, Testing Labs.	Testing of Appliances.
		W. C. Cole, Approvals Engineer, Canadian Standards Association.	
	National Housing Administration	Raymond Card, Regional Director	General.
	Wartime Housing Ltd., 30, Bloor Street West.	W. L. Somerville, Vice-President	General.
Urbana (Ill.)	University of Illinois	Maurice K. Fahnestock	General and Warm Air Heating and Skirting Heating, Coking Furnace
		Prof. A. P. Kratz.	
		Prof. Seichi Konzo.	
		Prof. Fellowes.	
		W. S. Harris.	
Utica	International Heater Co.	H. F. Randolph	Warm Air Panel Heating.
Washington (D.C.)	National Housing Agency	Coleman Woodbury, Asst. Commissioner	
	National Housing Agency, Longfellow Building, Connecticut Avenue.	Jacob Crane, Director	Administration and General.
		Clarence Farrier, Tech. Divn.	
		Holmes Perkins.	
		Mr. Voell (Tech. Divn.).	
		L. Shuman (Tech. Divn.).	
	Federal Public Housing Authority, Longfellow Building, Connecticut Avenue.	R. J. Wadsworth, Architect	Administration and General.
		V. Manus, Engineer.	
		Elizabeth Coit, Housing.	
		Miss Vorres, Statistics.	

Town	Association or Firm and Address	Name and Title of Individual	Subject
Washington (D.C.) —contd.	Federal Housing Administration, 15th and K. Street.	Robert K. Thulman	Administration and General.
		Mr. Sluder.	Details of many Appliances under development.
	British Commonwealth Scientific Office, Du Pont Circle Building.	Mr. Mullen	General.
	Bureau of Standards	R. S. Dill, Chief of Heat Transfer Divn.	Testing.
		P. R. Achenbach, Heat Transfer Divn.	
		Mr. Fairchild, Divn. of Trade Standards.	Standards.
	Bureau of Home Economics	Dr. Hazel Stiebling, Chief of Bureau ..	Statistics.
	Office of Price Admin., 2,228, Federal Office Building, No. 1, 2nd and D. Street.	Dr. Graves	Statistics.
	Washington Gas Co., 10th Street ..	Leon Ousoroff	Gas Appliances.
	American Society of Heating and Ventilating Engineers.	District Meeting	
	Dept. of Agriculture, South Agricultural Building.	Dr. Lickert	Heating Surveys.
		Angus Cambell.	
	Bureau of Mines	Dr. Fieldner	Fuel Distribution and General.
		Mr. Carman.	

Appendix 5

STATISTICAL TABLES

This Appendix gives statistics relating to fuel production, estimated domestic fuel consumption, fuel usage for heating and cooking, types of heating appliances, gas manufacture and electricity generation for the whole of the U.S.A., together with types of heating appliances, fuel usage for heating and cooking, fuel prices and weather conditions for the cities visited. Some of the figures have been included in Tables in the main report. Statistics relating to the production of fuel in the U.S.A. and its use for domestic purposes appear in Table 5 of the main report and are not repeated here.

The figures are taken from U.S. Government publications, and the published statistics of the American Gas Association and the Edison Electric Institute.

The figures in general relate to the year 1939 so as to eliminate as far as possible the effect of the war. Weather statistics cover the periods over which figures are available. Prices of solid fuels and oil in the various cities are for November, 1944, and are not substantially different from those in 1939. Typical electricity bills are for January, 1944, and typical gas bills for March, 1944.

TABLE 15

Abstracted Statistics from 1940 U.S.A. Housing Census

	Urban	All
All dwelling units	21,616,352	37,325,470
Private families	17,372,524	29,904,663
Population	74,423,702	131,669,275
Population per occupied unit	3·61	3·78
	Per cent.	Per cent.
Dwelling units with running water	93·5	69·9
Dwelling units with exclusive use of bath or shower	77·5	56·2
	Per cent.	Per cent.
Dwelling units with electric light	95·8	78·7
	Per cent.	Per cent.
Main cooking fuel—Coal or coke	8·0	11·5
Wood	6·0	23·6
Gas	73·0	48·8
Electricity	5·1	5·4
Kerosene or gasoline	6·9	9·7
	Per cent.	Per cent.
Dwelling units with mechanical refrigeration equipment	56·0	44·1
Dwelling units with ice boxes	31·6	27·1
	Per cent.	Per cent.
Heating equipment—with central heating—		
Steam or hot water	32·8	21·8
Piped warm air	22·2	16·8
Pipeless warm air	3·3	3·5
Heating equipment—without central heating—		
Heating stove	35·1	46·6
Other or none (including fireplaces)	6·7	11·3
	Per cent.	Per cent.
Dwellings using specified fuels for space heating as per cent. of total dwellings—		
Coal or coke	64·2	54·7
Wood	5·9	22·8
Gas	15·6	11·3
Fuel oil	11·3	8·6
Kerosene or gasoline	1·7	1·4
	Per cent.	Per cent.
Dwellings using specified fuels in central heating plants as per cent. of total dwellings—		
Coal or coke	77·5	77·0
Wood	1·0	2·6
Gas	8·5	7·8
Fuel oil	12·3	11·9
	Per cent.	Per cent.
Dwellings using specified fuels in non-central heating plants as per cent. of total dwellings—		
Coal or coke	45·8	38·6
Wood	12·6	37·3
Gas	25·5	13·8
Fuel oil	9·9	6·2
Kerosene or gasoline	4·0	2 5

TABLE 16

FUEL USED IN THE MANUFACTURED GAS INDUSTRY (1939)

(From *the American Gas Association Annual Statistics of the Manufactured Gas Utility Industry Statistical Bulletin No.* 52)

Anthracite	199,000 tons (2,000 lb.)
Bituminous coal	6,502,000 tons (2,000 lb.)
Coke purchased	642,000 tons (2,000 lb.)
Oil	627,001 thousand U.S. gals.

1,404,000 tons of the coke made together with 339,000 tons of coke breeze is used in the plant.

TABLE 17

GAS PRODUCED AND GAS PURCHASED BY THE MANUFACTURED GAS INDUSTRY, (1939)

(From *the American Gas Association Annual Statistics of the Manufactured Gas Utility Industry Statistical Bulletin No.* 52)

		Million cu. ft.
Gas produced—	Water gas	156,158
	Coke oven gas	53,073
	Retort coal gas	15,072
	Oil gas	5,857
	Reformed oil refinery gas ..	5,886
	Reformed natural gas	2,806
	Butane-air gas	1,445
	TOTAL produced	240,297

		Million cu. ft.
Gas purchased—	Coke oven gas	88,018
	Oil refinery gas..	6,094
	Natural gas for mixing ..	52,105
	TOTAL purchased	146,217

	Million cu. ft.
TOTAL manufactured and mixed gas	386,514

TABLE 18

Gas Sales and Revenues (1939)

	Manufactured and Mixed Gas		Natural Gas	
	Million cu. ft.(1)	Million therms(2)	Million cu. ft.(1)	Million therms(3)
Total sales	358,683	2,152	1,332,299	13,989
Domestic sales	191,465	1,149	374,110	3,928
House heating sales	55,309	332		
Number of customers—				
Domestic	9,210,000		6,989,000	
House heating	260,000			
Average revenue—				
Domestic	132 c/1,000 cu. ft.	22 c/therm	69 c/1,000 cu. ft.	6·5 c/therm
House heating	61 c/1,000 cu. ft.	10 c/therm		
Average annual sales per customer—				
Domestic	20,800 cu. ft.	125 c/therm	53,300 cu. ft.	560 therm
House heating	212,700 cu. ft.	1,274 c/therm		
Average annual revenue per customer—				
Domestic	$27·36		$36·98	
House heating	$129·57			
Number of meters—				
Total	9,882			
Prepayment	147			

(1) From the American Gas Association Annual Statistics of the Manufactured Gas and Natural Gas Utility Industries (Statistical Bulletins 52 and 53.)

(2) Calculated on an assumed calorific value of 600 B.Th.U. per cu. ft.

(3) Calculated on an assumed calorific value of 1,050 B.Th.U. per cu. ft.

TABLE 19

TOTAL GENERATION OF ELECTRICITY IN U.S.A. (1939)

(From *Statistical Bulletin No.* 11 *of the Edison Electric Institute*)

[By Electric Utility Companies, Municipal Electric Utilities and Government Power Districts]

Steam plants	82,510 million kW. hr.
Hydro	43,392 million kW. hr.
Internal Combustion	1,286 million kW. hr.
TOTAL	127,188 million kW. hr.

TABLE 20

FUEL CONSUMPTION FOR ELECTRICITY GENERATION (1939)

(From *Statistical Bulletin No.* 11 *of the Edison Electrical Institute*)

Coal or coke	46,223,000 tons (2,000 lb.)
Fuel oil	17,423,000 barrels (42 U.S. gals.)
Gas	191,131,000 thousand cu. ft.
Total coal equivalent ..	59,514,000 tons (2,000 lb.)
Pounds coal per kW. hr. generated	1·39

TABLE 21

ELECTRICITY REVENUE (1939)

(From *Statistical Bulletin No.* 11 *of the Edison Electric Institute*)

Average sale per domestic consumer	897 kW. hr per year
Average bill per domestic consumer	$35·88 per year
Average revenue per kW. hr. for domestic consumers	4 c.

TABLE 22

DOMESTIC USE OF ELECTRICITY IN 1939—ESTIMATED ALLOCATION

(*From Statistical Bulletin No.* 11 *of the Edison Electric Institute*)

	Million kW. hr.
Lighting and miscellaneous	7,460
Refrigeration	4,632
Cookers	2,147
Water heaters	1,630
Radios and phonographs	1,880
Flat-irons	1,538
Oil burners, washing machines, vacuum cleaners, clocks, ironing machines, etc.	1,863
	21,150

TABLE 23

STATISTICS RELATING TO VARIOUS CITIES VISITED

1. Climate and methods of Heating

	Boston	Charleston, S.C.	Chicago	Cleveland	Columbus, Ohio	Detroit	New York	Pittsburg	Portland, Oreg.	St. Louis	Seattle	Washington, D.C.
Population (*a*)	770,816	71,275	3,396,808	878,336	306,087	1,623,452	7,454,996	671,659	305,394	816,048	368,302	663,091
Occupied dwelling units (*a*)	197,393	20,410	949,744	242,267	83,597	425,547	2,047,919	175,163	102,063	234,872	126,354	173,445
	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.	°F.
Mean January Temperature (*b*)	28·5	50·4	22·3	26·5	29·6	24·9	30·9	31·0	39·4	31·1	40·3	33·4
Mean July Temperature (*b*)	72·1	81·6	72·7	71·4	75·4	72·7	73·8	74·3	66·7	78·8	64·3	76·8
Design Temperature (*c*)	0	+20·0	−10·0	− 5·0	−10·0	0	0	− 5·0	+15·0	− 5·0	+10·0	0
Total Annual Hours of Sunshine (*b*)	2,561	2,941	2,652	2,338	2,468	2,324	2,791	2,318	2,154	2,697	2,067	2,576
Total Hours Sunshine, Nov.–Jan. (*b*)	416	572	384	248	439	392	482	298	218	449	193	439
Degree Days (*c*)	5,943	1,870	6,287	6,171	5,536	6,580	5,306	5,466	4,379	4,610	4,864	4,598
PERCENTAGE OF DWELLINGS USING VARIOUS HEATING METHODS (*a*)												
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Steam or hot water	59·2	3·8	61·2	19·1	6·3	39·3	83·8	23·5	16·8	27·2	32·5	83·2
Piped warm air	10·0	1·0	10·1	54·0	61·6	42·1	1·6	33·5	52·1	34·5	34·9	3·7
Pipeless furnace	0·6	0·4	1·0	1·5	1·7	0·9	0·6	1·5	6·5	1·0	4·3	0·8
Heating stove	30·2	94·7	27·7	25·4	30·5	17·7	14·1	41·5	24·6	37·3	28·4	11·6

(*a*) U.S. Census of Housing, 1940.
(*b*) U.S. Department of Commerce Weather Bureau Statistics.
(*c*) American Society of Heating and Ventilating Engineers Guide.

TABLE 23—*contd.*

1. Climate and methods of Heating—contd.

	Boston	Charleston, S.C.	Chicago	Cleveland	Columbus, Ohio	Detroit	New York	Pittsburg	Portland, Oreg.	St. Louis	Seattle	Washington, D C.
PERCENTAGE OF DWELLINGS USING DIFFERENT FUELS FOR HEATING (*a*)												
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Piped or Ducted Systems—												
Coal or coke	51·7	1·3	66·6	69·2	62·8	73·1	65·4	51·2	4·6	58·3	23·3	56·5
Wood	0·1	0·1	—	—	0·1	—	—	—	35·5	—	5·4	—
Gas	1·1	—	1·6	3·9	5·3	4·4	1·6	5·7	4·7	1·5	1·8	10·5
Fuel oil	13·4	2·7	2·7	0·2	0·2	3·4	14·2	0·1	27·4	2·4	38·5	23·4
Stoves, etc.—												
Coal or coke	7·9	12·5	19·4	18·4	23·4	15·4	8·4	30·9	0·7	36·1	9·6	9·2
Wood	0·2	30·3	0·1	—	—	—	0·2	—	23·1	0·1	12·7	0·1
Gas	0·3	1·7	0·5	7·2	7·7	0·6	0·7	12·1	0·7	0·3	0·5	—
Fuel oil	15·6	20·9	7·9	0·3	—	2·2	3·8	—	3·2	1·3	8·1	0·1
Kerosene or Gasoline ..	6·6	29·1	—	—	—	—	2·1	—	0·1	—	0·1	0·2
PERCENTAGE OF DWELLINGS USING DIFFERENT FUELS FOR COOKING (*a*)												
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Coal or coke	9·5	1·0	4·2	2·5	4·3	3·6	2·7	3·7	0·2	12·2	9·8	5·5
Wood	0·3	24·1	0·1	0·1	—	0·1	0·3	0·1	24·5	0·2	16·7	1·8
Gas	67·7	35·3	93·8	96·0	93·7	90·8	94·6	95·8	42·0	81·3	29·0	85·8
Electricity	1·5	3·9	0·6	0·6	0·8	4·4	1·2	0·1	32·6	2·7	40·6	3·5
Kerosene or Gasoline ..	17·7	34·9	0·6	0·3	1·0	0·7	0·7	0·1	0·2	3·1	0·6	2·0
Other..	2·4	0·1	0·1	—	—	—	0·1	—	0·1	0·2	1·3	0·1
None	0·9	0·7	0·5	0·4	0·2	0·4	0·4	0·2	0·4	0·4	2·0	1·3

(*a*) U.S. Census of Housing, 1940.

TABLE 23—*contd.*

2. *Fuel Prices*

	Boston	Charles-ton, S.C.	Chicago	Cleve-land	Colum-bus, Ohio	Detroit	New York	Pitts-burg	Port-land, Oregon	St. Louis	Seattle	Wash-ington, D.C.
RETAIL PRICE, 15th NOV., 1944 (*d*)	$	$	$	$	$	$	$	$	$	$	$	$
Anthracite, per ton of	15·64	17·85	16·84	15·59	—	15·08	13·97	—	—	16·04	—	14·97
2,000 lb.	11·94	13·50	13·49	15·59	—	11·94	9·81	—	—	14·45	—	11·05
Low volatile bituminous	11·52	11·45	12·91	11·08	9·49	11·36	9·54	—	—	10·67	—	12·45
coal, per ton of 2,000 lb.	9·92	9·65	10·05	9·72	8·31	9·99	9·50	—	—	9·94	—	8·84
High volatile bituminous	9·94	11·25	11·57	9·43	8·13	10·11	—	6·33	14·65	7·38	15·11	10·05
coal, per ton of 2,000 lb.	—	9·25	8·30	8·62	7·67	9·11	—	5·14	11·94	6·98	11·60	9·64
Coke, per ton of 2,000 lb. ..	14·97	12·28	15·09	12·47	11·29	12·71	14·73	12·28	—	—	—	13·54
Briquettes, per ton of 2,000 lb.	14·34	14·28	12·97	—	10·42	—	—	—	—	11·76	—	12·24
Fuel oil, per 100 U.S. galls.	9·00	10·80	7·96	8·55	—	8·45	9·09	—	7·30	8·47	7·78	10·30
(83 Imp. galls.)	—	8·70	7·45	8·03	—	7·42	—	—	6·30	7·55	6·75	9·40
Wood, per 128 cu. ft. ..	10·40	—	—	25·75	—	—	29·29	26·10	10·50	16·27	12·65	—
Kind of gas (*e*)	Manu-factured	Manu-factured	Mixed	Natural	Natural	Natural	Manu-factured	Natural	Manu-factured	Mixed	Manu-factured	Mixed
Composition of Mixed Gas: (*e*)												
Natural, per cent. ..			73·2							39·7		27·6
Manufactured, per cent.			26·8							60·3		72·4
Heating value, B.Th.U. cu. ft. (*e*)	528	550	800	1,075	1,050	1,014	537	1,115	570	800	500	600

(*d*) U.S. Department of Labour. Bureau of Labour Statistics. Maximum and minimum prices for the various sizes of solid fuel are given.

(*e*) "Typical Gas Bills" Report to U.S. Senate. 77th Congress, 1st Session, Document No. 122. 1941.

TABLE 23—*contd.*

2. *Fuel Prices*—contd.

	Boston	Charleston, S.C.	Chicago	Cleveland	Columbus, Ohio	Detroit	New York	Pittsburg	Portland, Oregon	St. Louis	Seattle	Washington, D.C.
TYPICAL MONTHLY GAS BILLS (*e*)												
Minimum bill	0·58	0·50	0·60	0·80	0·75	0·86	1·00	1·00	0·71	0·75	0·75	0·75
Per therm—												
For 5 therms (*f*)	0·35	0·25	0·21	0·17	0·15	0·17	0·26	0·20	0·26	0·24	0·29	0·16
For 15 therms (*g*)	0·23	0·25	0·17	0·09	0·07	0·13	0·20	0·07	0·21	0·17	0·18	0·14
For 35 therms (*h*)	0·19	0·21	0·14	0·07	0·06	0·12	0·16	0·05	0·17	0·14	0·15	0·13
For 100 therms (*i*)	0·13	0·15	0·10	0·06	0·05	0·08	0·12	0·05	0·10	0·09	0·11	0·11
For 250 therms (*i*)	0·11	0·13	0·08	0·05	0·05	0·07	0·10	0·05	0·08	0·07	0·08	0·10
TYPICAL MONTHLY ELECTRIC BILLS (*j*)												
Minimum bill	0·75	1·00	0·50	0·60	0·50	0·45	0·90	0·50	0·85	0·50	0·75	0·75
Per kW. h.—												
For 15 kW. h. (*k*)	0·06	0·07	0·05	0·04	0·04	0·04	0·08	0·05	0·06	0·05	0·05	0·05
For 25 kW. h. (*k*)	0·06	0·06	0·05	0·04	0·05	0·04	0·07	0·05	0·03	0·05	0·04	0·04
For 40 kW. h. (*k*)	0·06	0·05	0·05	0·04	0·04	0·04	0·06	0·05	0·03	0·04	0·03	0·03
For 100 kW. h. (*l*)	0·05	0·04	0·04	0·03	0·04	0·03	0·05	0·04	0·03	0·03	0·03	0·03
For 250 kW. h. (*m*)	0·04	0·03	0·03	0·03	0·03	0·03	0·03	0·03	0·02	0·02	0·02	0·02
For 500 kW. h. (*m*)	0·02	0·02	0·02	0·02	0·03	0·02	0·03	0·02	0·01	0·02	0·01	0·02

(*e*) "Typical Gas Bills" Report to U.S. Senate. 77th Congress, 1st Session, Document No. 122. 1941.
(*f*) Probably used principally for cooking.
(*g*) Probable use—cooking and water heating.
(*h*) Probable use—cooking, water heating and refrigeration.
(*i*) Probable use—cooking, water heating and house heating.
(*j*) "Typical Electric Bills". U.S. Federal Power Commission. 1944.
(*k*) Probable use—lighting and small appliances.
(*l*) Probable use—lighting, small appliances and refrigeration.
(*m*) Probable use—lighting, small appliances, refrigeration and cooking.

Appendix 6

LIST OF LITERATURE OBTAINED

Below is a list of the literature collected from U.S.A. and Canada. It has not been possible to study all of this during the preparation of this Report.

1. FUELS AND APPLIANCES.

(*a*) *United States of America*

ANTHRACITE INDUSTRIES, INC.

Advantages and methods of heating service water with Pennsylvania anthracite.

Report No. 10–*B*.—Laboratory Bulletin describing approved equipment. (1941)
Laboratory Bulletin No. S–10B.—Automatic stokers.
Laboratory Bulletin No. 33.—Supplementary house heating with modine unit heaters.
Laboratory Bulletin No. 34.—F. and E. anthracite stoker.
Laboratory Bulletin No. 36.—Quick meal automatic stoker coal range.
Laboratory Bulletin No. 37–1.—Spencer automatic steel tubular boilers.
Laboratory Bulletin No. 42.—Spencer automatic magazine feed heaters.
Approved equipment for use with Pennsylvania anthracite. (1941).
New principles of burning anthracite.
Performance of anthracite-fired water heaters : *R. C. Johnson*. Reprinted from the Trans. of the 4th Annual Anthracite Conference of Lehigh University, 1941.
Paper II. Inherent characteristics of anthracite : *H. J. Rose*. (As above, 1st Conference, 1938).
Paper III. Natural advantages of anthracite : *H. J. Rose*. (As above, 2nd Conference, 1939).
Evaluating performance of water heaters fired with solid fuels : *H. J. Rose* and *R. C. Johnson*. Reprinted from A.S.H.V.E. Journal.
Winkler fully automatic stokers for anthracite : *U.S. Machine Corp.*, Lebanon, Indiana.
Anthracite industries manual of anthracite as a domestic fuel.
Illustrated reports on water heaters.

AMERICAN GAS ASSOCIATION

Research Bulletin No. 1.—Flow of gas through orifices of domestic gas appliances.
Research Bulletin No. 15.—Combustion of Gas with Limited Air Supply.
Research Bulletin No. 16.—Relation of Burner Volume to Ignition and Extinction Characteristics of Gas Range Top Burners.
Research Bulletin No. 17.—Automatic Flash Tube and Pilot Ignition of Oven and Boiler Burners on Manufactured Gas.
Research Bulletin No. 18.—Gas Summer Air Conditioning.
Research Bulletin No. 19.—Effect of Cold Inlet Water on Performance of Automatic Storage Gas Water Heaters.

Research Bulletin No. 20.—Gas Burners using all Air for Combustion as Primary Air.

Research Bulletin No. 21.—Single Point Flash Tube Ignition of Oven and Boiler Burners.

Research Bulletin No. 22.—Primary Air Control Devices for Atmospheric Gas Burners.

Research Bulletin No. 23.—Performance Characteristics of Gas Range Top Sections Equipped with Atmospheric Burners.

Research Bulletin No. 24.—Research on Immersion Tube Heating with Gas.

Research Bulletin No. 25.—A study of Fundamentals of Resonant Noise in Gas Furnaces.

Research Bulletin No. 26.—Primary Air Injection Characteristics of Atmospheric Gas Burners.

Research Bulletin No. 27.—A Study of Performance Characteristics of Vented Domestic Gas Ranges.

Research Bulletin No. 28.—Electric Ignition of Gases.

Research Bulletin No. 29.—Principles of Design and Sizing of Automatic Gas Water Heaters for Maximum Service Efficiency.

Research Bulletin No. 30.—Gas Summer Air Conditioning: Performance Characteristics of Air Duct Systems and Review of Methods for Design and Calculation of Pressure Losses in these systems.

Research Bulletin No. 31.—Gas Summer Air Conditioning: Survey of Water Problems encountered with Summer Air Conditioning Equipment.

Research Bulletin No. 32.—Non-Aerated Burners.

Research Bulletin No. 33.—Design Features affecting Gas Range Surface Temperatures.

Research Bulletin No. 34.—Temperature as a Factor in the Design of Aerated Gas Burners.

Bulletin No. 5.—Investigation on the Effect of " Gas Savers " on the Performance of Gas Appliances.

Gas Utility Recommendations for Post-War Gas Appliance Design :—

Part I.—Gas Ranges and Co-ordinated Gas Kitchens.

Part II.—Gas Refrigerators.

Part III.—Gas Water Heaters.

Approved gas appliances and listed accessories, 1944.

Winter-Summer water heating from gas-fired boilers—coil water heating proves its case.

Bulletin No. 7.—Domestic gas range research.

Bulletin No. 12.—Principles of water heater design for maximum gas storage hot water delivery. (1941).

Gas cooking :—A 10 to 1 favourite over electricity in urban and surburban homes : *T. J. Shanley*. Reprinted from the *American Gas Association Journal* for December, 1942.

Interim Bulletin No. 55.—Cooking survey, 1939.

Interim Bulletin No. 56.—Points and paragraphs on gas refrigeration.

Interim Bulletin No. 67.—Uncle Sam wants it to last. (The care and correct use of gas equipment).

Gas range cookery chart.
Gas range vegetable cookery chart.
High lights of the gas utility industry in 1944 : *J. French Robinson.*

MELLON INSTITUTE OF INDUSTRIAL RESEARCH

Progress report on methods of banking anthracite in hand-fired equipment.
Memorandum on meeting of Anthracite Engineers at Mellon Institute, Pittsburgh, September 25th, 1942.

PURDUE UNIVERSITY

Engineering Bulletin, 1939, *23* (1), *Research Series* No. 64. Improved hot water supply piping : *J. M. Krappe.*
Engineering Bulletin 1940, *24* (3A), *Research Series* No. 74. Scale formation in water heaters and methods of prevention : *J. M. Krappe.*

UNDERWRITERS' LABORATORIES, INC.

Miscellaneous Hazard 2962, June 16th, 1943. Report on "Vitroliner" flue-type E, Condensation Engineering Corporation, Chicago, Ill.
New Markel built-in wall Heetaires. Tested and listed under re-examination service by Underwriters' Laboratories, Inc. Markel Electric Products, Inc.
List of inspected gas, oil and miscellaneous appliances. December, 1943.

UNIVERSITY OF ILLINOIS

Bulletin 1944, *41*, (20), *Engineering Experiment Station Bulletin* No. 349. Performance of a hot-water heating system in the I.B.R. Research Home at the University of Illinois : *A. P. Kratz*, *W. S. Harris*, *M. K. Fahnestock* and *R. J. Martin.*

CITY OF ST. LOUIS

Official firing instructions for low volatile fuel. (1940).
Coal contract between Rawie Coal Company and St. Louis Housing Association.

CITY OF PITTSBURGH

Ceramic-tile space heater. "Broadhead Manor," Pittsburgh.

EDWARDS MANUFACTURING CO. (Cincinatti, Ohio)

Firedaire—a fireside furnace.

CHIMNEY FURNACE ENGINEERING CO. (Seattle, Wash.)

Why chimney furnaces are better to make and sell than the pre-war furnaces of 1940.
Drawings of fireplace chimney furnaces for coal or wood, with or without water heater.

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF MINES

Information Circular No. 7261. Recent developments in fuel supply and demand : *A. C. Fieldner.* (November, 1943).
Technical Paper 576.—Bibliography of coal and its products, 1910–35. (1937).

Technical Paper 639.—Bibliography of coal and its products, 1935–40. (1942).
Bulletin 404.—Burning of coal and coke treated with Small Quantities of Chemicals. (1937).
Bulletin 446.—Typical analysis of coals of U.S.A. (1942).
Report of Investigation 3757.—Packaged fuel. (1944).
Mineral Market Report 1175.—Fuel briquettes and packaged fuel in 1943. (1944).

FEDERAL HOUSING ADMINISTRATION

Minimum requirements for oil burners: *R. K. Thulman*. (Talk delivered at meeting of Oil Burner Institute, Philadelphia, Pa. October 12th, 1938.)

U.S. DEPARTMENT OF COMMERCE. NATIONAL BUREAU OF STANDARDS

Letter Circular 419.—Information on refrigeration. (1934).
Letter Circular 472.—Domestic electric and gas refrigerators. (1936).
Letter Circular 738.—Notes on domestic fuel oil conservation. (1943).
Reports on coal ranges, space heaters, etc. (*CONFIDENTIAL*).

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS and the U.S. DEPARTMENT OF AGRICULTURE

B—1933. Barbecue and utility furnaces.
Prevent home fires.
Fireless cooker.
Keeping the pledge (fire precautions).

MOTOR WHEEL CORPORATION, DUO–THERM DIVISION. (Lansing, Mich.)

Duo-therm automatic oil burning furnaces and water heaters.
Setting a new style in home heating.

VERTICAL FIREPLACE STOVE COMPANY. (New York)

Vertical grate.

COAL HEAT MAGAZINE (Chicago)

Boiler heating, furnace heating, stove heating, and stoker heating guides: *K. C. Richmond*.

HEATILATOR COMPANY

Heatilator fireplace.

SCHUMAKER–KELLY CO. INC.

Portable grates and Franklin stoves.

SKUTTLE SALES CO.

Durastac—vitreous enamel-lined chimney.

A.M. BYERS COMPANY, PITTSBURGH, PA.

Wrought iron for tank construction.
Wrought iron for flue gas conductors and coal handling equipment.

UNIVERSITY OF MINNESOTA

Engineering Experiment Station, Bulletin No. 20.—Conservation of fuel: *F. B. Rowley* and *C. E. Lund* (July, 1943).

(*b*) *Canada*

DOMINION BUREAU OF STATISTICS

Coal statistics for Canada for the year 1942.
How to burn coke.
How to burn hand-fired bituminous coal.
Special statement—stoves, 1943.
Special statement—warm air furnaces, 1943.

DEPARTMENT OF MINES, BUREAU OF MINES

How to burn bituminous coal or anthracite and bituminous mixtures in domestic heating appliances.
Instructions for burning coal, coke and peat, 1927.
Investigations of Canadian coals, including their testing, classification and utilisation: *B. F. Haanel* and *R. E. Gilmore.* (Engineering Institute of Canada, 1937).
Memorandum No. 37.—Coke as a fuel for domestic purposes: *C. E. Baltzer.* (1929).
Memorandum No. 56.—Summary of tests on British Columbia coals when used as pulverised fuel: *E. S. Malloch.* (1932).
Memorandum No. 73.—Summary of tests made on three domestic-type wood-burning hot water boilers: *C. E. Baltzer* and *E. S. Malloch.* (1939).
No. 705.—Comparative tests of various fuels when burned in a domestic hot-water boiler: *E. S. Malloch* and *C. E. Baltzer.* (1929).
No. 725–3.—Boiler tests on coals and other solid fuels. (1933).
No. 802.—Comparative tests of various fuels when burned in a domestic hot-water boiler, 1935–38: *C. E. Baltzer* and *E. S. Malloch.*
Relationship of ash constitution to clinkering in "blower" coals: *E. Swartzman.* Reprinted from "*Canadian Chemistry and Process Industries,*" December, 1943.
Memorandum re chemical treatment for controlling the clinkering characteristics of "blower" coals: *E. Swartzman.* (1943).

NATIONAL RESEARCH COUNCIL

Wood burning stoves: *S. J. Cook* (1937).
No. 24. Fuel saving possibilities in house heating.

CONSUMERS' GAS COMPANY, TORONTO

The deterioration of domestic chimneys. (1932).

NATIONAL SEWER PIPE COMPANY, LTD.

Prevent chimney fires—use vitrified clay flue lining.

UNIVERSITY OF TORONTO. SCHOOL OF ENGINEERING RESEARCH, FACULTY OF APPLIED SCIENCE AND ENGINEERING

Technical Memorandum No. 1.—1942. Producer gas for motor transport. A fuel policy for Canada: *E. A. Allcut.*

2. HEATING REQUIREMENTS, HEAT LOSSES, AND HEAT INSULATION

(*a*) *United States of America.*

JOHN B. PIERCE FOUNDATION

Research Study 2.—Summer comfort factors as influenced by thermal properties of building materials: *C. O. Mackey.*

Research Study 9.—Thermal properties of a floor in contact with the ground: *C. O. Mackey.* (1944).

The influence of heat capacity of walls on interior thermal conditions and heat economy: *C. E. A. Winslow, L. P. Herrington* and *R. J. Lorenzi.* (Reprint from A.S.H.V.E. Journal.)

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

Bulletin 1937, *8* (7), *Engineering Experiment Station Bulletin* No. 29. A study of thermal radiation: *J. R. D. Eddy* and *J. H. Nelson.*

Bulletin 1941, *12* (15), *Engineering Experiment Station Bulletin* No. 62. Heat requirements of intermittently heated buildings: *E. G. Smith.*

UNIVERSITY OF ILLINOIS

Bulletin 1944, *42* (12), *Circular Series* F.11.2. Storm windows for double-hung windows.

Effect of insulation on plant performance in the Research Residence. *A. P. Kratz* and *S. Konzo.* (*Heating, Piping and Air-conditioning, May,* 1941.)

Bulletin 1944, *41* (20), *Engineering Experiment Station Bulletin* No. 349. Performance of a hot-water heating system in the I.B.R. Research Home at the University of Illinois: *A. P. Kratz, W. S. Harris, M. K. Fahnestock* and *R. J. Martin.*

CITY OF ST. LOUIS

Building heating guide: *K. C. Richmond.* (1942).

PUBLIC UTILITY DISTRICT NO. 1, COWLITZ COUNTY, WASHINGTON

Electric house heating, Longview, Washington. (Analysis of electric heating.)

A. M. BYERS COMPANY, PITTSBURGH, PA.

A working method for calculating a floor type radiant heating system. (Reprinted from "*Plumbing and Heating Business*", September, 1941.)

Weather-controlled residential radiant heating system. *P. E. Frederick.* (Reprinted from "*Heating and Ventilating*", October, 1943.)

UNITED STATES HOUSING AUTHORITY. (FEDERAL WORKS AGENCY)

Bulletin No. 20. Selecting a method of heating. (Revised July, 1940.)

FEDERAL HOUSING ADMINISTRATION

Technical Circular No. 7. Calculation of building section : heat transmission co-efficients.

Heating the post-war house : *R. K. Thulman*. (Reprinted from " *Heating and Ventilating* ", March, 1944.)

U.S. DEPARTMENT OF THE INTERIOR. BUREAU OF MINES

Information Circular 7166. Home insulation, an effective conservation and national defense measure : *P. M. Tyler*. (April, 1941.)

U.S. DEPARTMENT OF COMMERCE. NATIONAL BUREAU OF STANDARDS

Letter Circular 445.—Painting of steam and hot water radiators. (July, 1935.)

Letter Circular 535.—Aluminium foil insulation. (Oct., 1938.)

Letter Circular 649.—Domestic heating and air conditioning. (May, 1941.)

Letter Circular 711.—Thermostat setting and economy in house heating. (December, 1942.)

Letter Circular 759.—Thermal insulation of dwelling houses. (July, 1944.)

Letter Circular 774.—Thermal insulation of dwelling houses. (January, 1945.)

NATIONAL BOARD OF FIRE UNDERWRITERS. UNDERWRITERS' LABORATORIES, INC.

Bulletin of Research No. 27.—Clearances and insulation of heating appliances. (February, 1943.)

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Design of automatic heating systems for low-cost residences : *R. K. Thulman*. (Reprinted from " *Heating and Ventilating* ", June, 1937.)

Heating low-cost homes : *R. K. Thulman*. (Reprinted from A.S.H.V.E. J. Section, " *Heating, Piping and Air-conditioning* ", 1939.)

The influence of heat capacity of walls on interior thermal conditions and heat economy : *C. E. A. Winslow*, *L. P. Herrington* and *R. J. Lorenzi*. (Reprinted from A.S.H.V.E. Journal.)

Radiation corrections for basic constants used in the design of all types of heating systems : *B. F. Raber* and *F. W. Hutchinson*. (Reprinted from " *Heating, Piping and Air-conditioning* ", Dec., 1944.)

Altitude chamber for study of heating and air-conditioning problems : *W. E. Crowell*. (Reprinted from " *Heating, Piping and Air-conditioning* ", October, 1944.)

FEDERAL PUBLIC HOUSING AUTHORITY

Central steam heating for large building groups : *P. A. Croney*. (Reprinted from " *Heating and Ventilating* ", November, 1944.)

AMERICAN MEDICAL ASSOCIATION

The importance of clothing in air conditioning : *C. P. Yaglou* and *A. Messer*. (Reprinted from *J. Amer. Med. Assoc.*, 1941, *117*, 1261-2.)

MASSACHUSETTS INSTITUTE OF TECHNOLOGY. (Cambridge, Mass.)

Solar energy records.
The performance of flat-plate solar heat collectors: *H. C. Hottel* and *B. B. Woortz.*

GREEN'S READY BUILT HOMES. (Rockford, Ill.)

The solar home.
Insulation and house design: *G. F. Keck.*

BETTER HOMES IN AMERICA

Home Information Service, 1936–37.
No. 4.—Thermal insulation of houses.

(*b*) *Canada.*

DOMINION FUEL BOARD

No. 3.—Central and district heating—possibilities of application in Canada: *F. A. Combe.* (1924.)
No. 8.—Why you should insulate your home: *G. D. Mallory.* (1927.)
No. 12.—Humidity in house heating: *E. S. Martindale.* (1930.)
No. 14.—Comparison of the cost and convenience of house heating with various fuels: *E. S. Malloch.* (1929.)
No. 15.—The insulation of old and new houses: *G. D. Mallory.* (1932.)

HOUSING ADMINISTRATION, OTTAWA

Insulation; Manual of insulation and heat loss calculations: *J. J. Hyland.* (1942.)

NATIONAL RESEARCH COUNCIL

No. 332.—On the testing of fibre-board insulation.
No. 700.—The coefficient of heat transfer for vertical surfaces in still air.
No. 728.—The influence of thickness on the measured thermal conductivity of fibre-board and rock wool.
No. 868.—Heat leakage through floors in cold storage plants.
No. 874.—The optimum thickness of insulation for Canadian homes.
No. 1055.—House insulation in its relation to Canada's war effort.
No. 1227.—Heat loss through windows. (Revised.)
Thermal conductivity of insulating materials: *E. A. Allcut* and *F. G. Ewens.*

UNIVERSITY OF TORONTO. SCHOOL OF ENGINEERING RESEARCH, FACULTY OF APPLIED SCIENCE AND ENGINEERING

Bulletin 140–1933.—Further tests on heat output of concealed radiators: *E. A. Allcut.*
Bulletin 149–1937.—Heat insulation as applied to buildings and structures: *E. A. Allcut* and *F. G. Ewens.*
Bulletin 158–1939.—Physical structure of heat insulating materials. Air infiltration.
Bulletin 169–1941.—Properties of heat insulating materials: *E. A. Allcut.*

3. SPECIFICATIONS AND TESTING.

(*a*) *United States of America.*

ANTHRACITE INDUSTRIES, INC.

*Laboratory Bulletin No. L.*39–A.—Procedure governing tests and approval by Anthracite Industries, Inc.

EDISON ELECTRIC INSTITUTE

Test specification for automatic electric storage water heaters. (Report of a *Joint Committee of the E.E.I. and the National Electrical Manufacturers' Association.*)

Test specification for household electric ranges. (Report of *Joint Committee*, 1940.)

NATIONAL ELECTRICAL MANUFACTURERS' ASSOCIATION

N.E.M.A. Standards for flat-irons. No. 40–61.

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS

Commercial Standards :

C.S. 113–44.—Oil-burning floor furnaces equipped with vaporising pot-type burners.
C.S. 109–44.—Solid-fuel-burning forced-air furnaces.
C.S. (E)104–43.—Warm-air furnaces equipped with vaporising pot-type oil burners.
C.S. (E)102–42.—Diesel and fuel oil engines (export classifications).
C.S. 101–43.—Flue connected oil-burning space heaters equipped with vaporising pot-type burners.
C.S. 99–42.—Gas floor furnaces, gravity circulating type.
C.S. 75–42.—Automatic mechanical-draught oil burners designed for domestic installations. (2nd Edition.)
C.S. 48–40.—Domestic burners for Pennsylvania anthracite (underfeed type). (2nd Edition.)
C.S. 12–40.—Fuel oils. (5th Edition.)
C.S. 0–40.—Commercial standards and their value to business (3rd Edition.)
C.S. 117–44.—Mineral wool : blankets, blocks, insulating cement, and pipe insulation for heated industrial equipment.
C.S. 105–43.—Mineral wool : loose, granulated, or felted form, in low-temperature installations.
C.S. (E) 90–41.—Crawler mounted, revolving power shovels, lifting cranes, dragline and clamshell excavators. (Export classification.)

[All above Commercial Standards are published by *U.S. Govt. Printing Office*, Washington, price 5 or 10 cents.]

Letter Circular 768.—List of Commercial Standards. (Revised to October 1st, 1944.)

T.S. 3443.—Proposed Commercial Standard (Emergency) for coal-burning space heaters ; as adopted by preliminary conference June, 1942, and adjusted by a special conference February, 1943.

T.S. 3560a.–Recommended Commercial Standard for testing and rating hand-fired hot water supply boilers (adopted by general conference, 1942, adjusted by special conferences, 1943, including items delegated to the Engineering Committee and approved by the Standing Committee). December, 1943.

T.S. 3738.—Draft of proposed Commercial Standard for coal-fired cooking ranges; (requested by National Housing Agency, Federal Public Housing Authority, and revised to suit composite comment from manufacturers and testing laboratories and submitted for further consideration by all concerned). May, 1944.

T.S. 3769.—Proposed Commercial Standard for prefabricated houses, as submitted by the Prefabricated Home Manufacturers' Institute and revised to suit subsequent composite comment.

NATIONAL BOARD OF FIRE UNDERWRITERS. UNDERWRITERS' LABORATORIES, INC.

Subject 103.—General information on tests of outlet and vent piping for gas appliances. (October, 1940).

Subject 210.—General information on examination and tests of flues for gas, oil or solid fuel domestic heating appliances. (August, 1943).

Subject 900.—General information on test procedure for air filters for air conditioning systems. (October, 1940).

Pamphlet No. 90.—Standards for installation of air conditioning, warm air heating, air cooling and ventilating systems. (August, 1942).

Testing for safety. (April, 1942).

General list of standards. (October, 1944).

ELECTRICAL TESTING LABORATORIES (New York)

Paper testing.

Electric water heater tests.

The measurement of colour.

Testing of air conditioners.

Electric range testing.

Technical services for Government contracts.

Tentative specifications for flat-irons (A.C. and D.C.); 41–16, 21–22.

Tentative specifications for table broilers; 41–19.22.

Tentative specifications for vacuum cleaners; 21.10.2.

Tentative specifications for sun lamps; 91.10.2.

Translation of German V.D.E. specification for electrically heated appliances.

NATIONAL WARM AIR HEATING AND AIR CONDITIONING ASSOCIATION, (CLEVELAND)

No. 7.—Code and manual for design and installation of warm air heating and air conditioning systems.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Survey of testing methods and rating units for domestic heating devices: *R. S. Dill.* (January, 1945.)

AMERICAN STANDARDS ASSOCIATION

Proposed American Standards Association practice on public approval and certification procedures. Z.34. 1/19. (August, 1944).

(*b*) *Canada*

DEPARTMENT OF MINES, BUREAU OF MINES

No. 761.—Wood fuel burning tests: *E. S. Malloch* and *C. E. Baltzer* (1935).

CANADIAN GOVERNMENT PURCHASING STANDARDS COMMITTEE

No. 18.—GP—1—1940.—Specification for coal.

NATIONAL RESEARCH COUNCIL

No. 726.—Air conditioning. A list of codes, regulations and standards.
No. 814.—Report on the A.S.T.M. Standard Specifications for classification of coals by rank and by grade and their application to Canadian coals. (1939).
No. 923.—National Building Code requirements bearing on health and sanitation.
No. 1068.—National Building Code.

CANADIAN STANDARDS ASSOCIATION

List of C.S.A. Standards. October, 1944.

Canadian Electrical Code. Part 2. Specification No. 0. Requirements and minimum standards covering electrical equipment.

4. RESEARCH PROGRAMMES AND PROGRESS REPORTS

(*a*) *United States of America.*

INSTITUTE OF GAS TECHNOLOGY

A progress report on the Institute of Gas Technology: *J. I. Yellott.* (Reprinted from "*Gas*," September, 1944).
A programme of research for the manufactured gas industry, 1944.
A summary of current research in the field of gas production now being conducted by the Institute of Gas Technology, 1944. [*CONFIDENTIAL*]

AMERICAN GAS ASSOCIATION

A plan for research and promotional development in the gas industry.

PURDUE RESEARCH FOUNDATION

Its organisation and purpose. Bulletin No. 1, revised 1944.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Research projects of importance to the profession and the industry, 1944.

BATTELLE MEMORIAL INSTITUTE

Research in action, 1944.
" Bituminous Coal Research." 1941, *1* (1).

BITUMINOUS COAL RESEARCH, INC.

A new five-year research programme.

(*b*) *Canada.*

DOMINION FUEL BOARD

Second progress report of the Dominion Fuel Board, 1923–28.

DEPARTMENT OF MINES, BUREAU OF MINES

The Fuel Research Laboratories at Ottawa and the scope of their investigations: *F. B. Haanel.* (Reprinted from the *Canadian and Mining Metallurgical Bulletin*, October, 1929).

5. STATISTICAL DATA.

(*a*) *United States of America.*

ANTHRACITE INDUSTRIES, INC.

Manual of statistical information on the Pennsylvania anthracite industry, 1944.
Pennsylvania anthracite production in 1942.
Production of appliances during 1939.

AMERICAN GAS ASSOCIATION

Statistical Bulletin No. 50, 1943.—Comparative Data on Gas-Fired Central Heating Installation.
Statistical Bulletin No. 52, 1943.—Annual statistics of the manufactured gas utility industry in 1942.
Statistical Bulletin No. 53, 1943.—Annual statistics of the natural gas utility industry in 1942.
Gas revenues in 1942 of Class A and B electric companies in per cent. of combined electric and gas revenues including companies with 10 per cent. or more gas revenues.

EDISON ELECTRIC INSTITUTE

Statistical Bulletin No. 11.—The electric light and power industry in the United States, 1943.

CITY OF ST. LOUIS

Statistics.—Number of bedrooms for dwelling unit (Clinton Peabody Terrace and Carr Square Terrace). Income limits and rental grades for war workers . . . rates.

U.S. DEPARTMENT OF AGRICULTURE (WEATHER BUREAU)

Annual Meteorological Summary with comparative data :—

Wilmington, N.C.	1935.	Compiled by *P. Hess.*
Syracuse, N.Y.	1938.	Compiled by *W. H. Tracy.*
St. Louis, Mo.	1939.	Compiled by *W. J. Moxom.*

U.S. DEPARTMENT OF COMMERCE (WEATHER BUREAU)

Climate of the States ; Annual Meteorological Summaries. (Reprinted from Department of Agriculture Year Book, 1941) :—

Agricultural Year Book Separate No. 1833.—Illinois.
Agricultural Year Book Separate No. 1834.—Indiana.
Agricultural Year Book Separate No. 1840.—Michigan.
Agricultural Year Book Separate No. 1847.—New England.
Agricultural Year Book Separate No. 1853.—Ohio.
Agricultural Year Book Separate No. 1855.—Oregon.
Agricultural Year Book Separate No. 1857.—S. Carolina.
Agricultural Year Book Separate No. 1862.—Virginia.
Agricultural Year Book Separate No. 1863.—Washington.

Annual Meteorological Summary with comparative data :—

Indianapolis, Ind. 1940. Compiled by *J. H. Armington.*
Cleveland, Ohio. 1943. Compiled by *C. G. Andru.*
New York, N.Y. 1943. Compiled by *J. H. Kimball.*
Seattle, Washington. 1943. Compiled by *L. C. Fisher.*
Portland, Or. 1943. Compiled by *E. L. Wells.*
Boston, Mass. 1943. Compiled by *G. H. Noyes.*
Columbus, Ohio. 1943. Compiled by *G. W. Mindling.*
Detroit, Mich. 1943. Compiled by *C. J. Root.*
Chicago, Ill. 1943. Compiled by *O. T. Lay.*
Denver, Col. 1943. Compiled by *M. B. Gittings.*
Norfolk, Va. 1944. Compiled by *F. B. Whitney.*
Washington, D.C. 1940. Compiled by *A. F. Magnum.*
New Haven, Conn. 1943.
Charleston, S.C. 1942 and 1943. *J. E. Lockwood.*
Pittsburgh, 19. Penn. 1943. Compiled by *W. S. Brotzman.*

Average hourly temperature (based on 53-year record), dew point, and relative humidity (based on 29-year hydrograph record), by months, for Washington, D.C.

[All the above Meteorological Data sheets are published by U.S. Government Printing Office, Washington, D.C.]

UNITED STATES DEPARTMENT OF COMMERCE. (BUREAU OF THE CENSUS)

Sixteenth census of the United States : 1940. Housing. Vol. 2. General characteristics. Part I : United States Summary. Prepared under the supervision of *Dr. L. E. Truesdell.* 1943. Containing Census Bureau Publications. (U.S. Government Printing Office.)

U.S. DEPARTMENT OF LABOUR. (BUREAU OF LABOUR STATISTICS)

Serial No. R.1224.—Co-operation in the building of homes : *F. E. Parker.* (Reprinted from the Monthly Labour Review of the Bureau of Labour Statistics, Feb. 1941.)

Serial No. R.1524.—Builders of 1-family houses in 11 areas, 1940 and 1941 : *A. C. Findlay.* (Prepared in the Bureau's Division of Construction and Public Employment and reprinted from the Monthly Labour Review, April, 1943.)

Serial No. R.1566.—New housing for war workers, 1940–43 : *A. C. Findlay.* (Prepared in the Bureau's Division of Construction and Public Employment and reprinted from the Monthly Labour Review, September, 1943.)

Serial No. R.1594.—Construction of 500 dollar houses in 1943 : *G. Schumm.* (Reprinted from the Monthly Labour Review, November, 1943.)

Serial No. R.1613.—Productivity in electric energy generation : *C. S. Gody* and *L. M. Walsh.* (Reprinted from the Monthly Labour Review, January, 1944.)

Serial No. R.1627.—Market prices of building materials in two wars : *T. P. Henson* and *J. W. Corbett.* (Reprinted from the Monthly Labour Review, March, 1944.)

Serial No. R.1628.—New Dwelling units in non-farm areas, 1942 and 1943 : *G. Schumm.* (Reprinted from the Monthly Labour Review, March, 1944.)

Serial No. R.1651.—Building construction in 1943. (Reprinted from the Monthly Labour Review, May, 1944.)

Serial No. R.1716.—Prices in the third quarter of 1944. (Reprinted from the Monthly Labour Review, December, 1944.)

Retail prices of fuel by cities, October 15th, 1944 : Preliminary report.
Retail prices of fuel by cities, November 15th, 1944 : Preliminary report.
Cost of living and retail costs of food. November, 1944.

UNITED STATES TREASURY DEPARTMENT

Public Health Reports 1932, *47* (36). Prevalence of communicable diseases in the United States. A study of the incidence and the time distribution of common colds.

COAL HEAT MAGAZINE

Distribution of stoves, furnaces and boilers by States, counties and cities : *K. C. Richmond* and *I. Smith.*

OFFICE OF PRODUCTION RESEARCH AND DEVELOPMENT

Extract from Quarterly Report for period ending December 31st, 1943.

NATIONAL HOUSING AGENCY

Letters giving statistics on rent for low cost housing : *W. P. Seaver* and *G. Wolfe.*

(*b*) *Canada.*

DOMINION FUEL BOARD

Fuels distributed for domestic heating, 1928–32.

DOMINION BUREAU OF STATISTICS

Census of industry, 1942 ; central electric stations in Canada.
Normal temperature and precipitation, 1885–1926.

DEPARTMENT OF MINES, BUREAU OF MINES

No. 698.—Industrial fuel and power statistics for Ontario, calendar year 1925: *E. S. Malloch* and *C. E. Baltzer.*

CONSUMERS' GAS CO. OF TORONTO

Market survey of appliances in use October 22nd, 1942. [*CONFIDENTIAL*]

6. ECONOMICS.

(*a*) *United States of America.*

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Fuel conservation programme.

UNIVERSITY OF ILLINOIS

Bulletin 1943, *41* (13), *Engineering Experiment Station Bulletin* No. 348. Fuel savings resulting from closing of rooms and from use of a fireplace: *S. Konzo* and *W. S. Harris.*

U.S. DEPARTMENT OF AGRICULTURE

Public experience with fuel oil rationing. Study 66—Report 42. (May, 1943.)

Miscellaneous Publication 432.—Family expenditures on housing; urban and village series. (1941.)

Miscellaneous Publication 436.—Family expenditure on furnishings; urban, village and farm. (1941.)

Miscellaneous Publication 457.—Family expenditures on housing; farm series. (1941.)

Miscellaneous Publication 520.—Rural family spending and saving in war-time. (1943.)

NATIONAL COAL ASSOCIATION

Map showing minimum price areas and production districts as set forth in the Bituminous Coal Act of 1937.

U.S. DEPARTMENT OF LABOUR. (BUREAU OF LABOUR STATISTICS)

Bulletin 648.—Family expenditures, 1935–36. Vol. I. Housing. Vol. IV. Furnishings and equipment.

Bulletin 723.—Spending and saving of the nation's families in wartime. (Prepared by the Cost of Living Division and reprinted with additional data, from the Monthly Labour Review, October, 1942.)

Bulletin 724.—Income and spending and saving of city families in wartime. (*Ibid*; the Monthly Labour Review, September, 1942.)

FEDERAL HOUSING ADMINISTRATION

Report to the Fuel Oil rationing branch on the technical aspects relating to the rationing of kerosene and fuel oils for space heating and domestic hot water heating: *L. E. Seeley* and *R. K. Thulman.*

FEDERAL POWER COMMISSION

Typical electric bills for cities of 50,000 population or more. (1944.)
Typical gas bills for cities of 50,000 population or more. (March, 1944.)

(*b*) *Canada.*

HOUSING ADMINISTRATION, OTTAWA

The labour value of the building dollar: *O. J. Firestone* and *F. W. Nicholls.* (1943.)

DOMINION BUREAU OF STATISTICS

Index numbers of cost of electricity for domestic service and tables of monthly bills for domestic service, commercial light and small power, 1943.

DEPARTMENT OF MUNITIONS AND SUPPLY

33 ways to save 1 ton in 5.

OFFICE OF THE COAL ADMINISTRATOR. THE WARTIME PRICES AND TRADE BOARD

Make your furnace fight. Save coal for the weapons of war.

7. HOUSING AND HOUSING PROGRAMMES.

(*a*) *United States of America.*

AMERICAN PUBLIC HEALTH ASSOCIATION

Basic principles of healthful housing. (2nd Edition.)

The improvement of local housing regulation under the law. Reprinted from the "*American Journal of Public Health*", November, 1942.

AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

Bulletin 1943, *14* (3), *Engineering Experiment Station Bulletin* No. 76. A low cost house for Texas: *C. J. Finney.*

UNIVERSITY OF ILLINOIS

Small Houses Council: Purposes and proposed programme.

CITY OF PITTSBURGH

Distribution of dwelling units and buildings. (Housing authority projects.) July, 1943.

WESTINGHOUSE ELECTRIC AND MANUFACTURING CO.

Electrically heated houses: *E. B. Dawson* and *J. F. Lamb.* (Reprinted from "*Electrical World*", 12th January and 23rd February, 1929.)

CITY HOUSING CORPORATION

Radburn presents "The home with a future".

NATIONAL HOUSING AGENCY

National Housing Bulletin 1.—Housing needs: a preliminary estimate. (November, 1944.)

National Housing Bulletin 3.—Standards for war housing, excluding temporary housing.

FEDERAL PUBLIC HOUSING AUTHORITY (MAY, 1942)

Housing facts and goals. Charts on the statement of Administrator *J. B. Blandford* before the Sub-committee on Housing and Urban Re-development of the Special Senate Committee on Post-war Economic Policy and Planning. (January, 1945.)

Digest of statements by *J. B. Blandford* before the above Sub-committee. (January, 1945.)

National Housing Agency's role in home financing. (December, 1944.)

Summarised description of National Housing Agency's programme and its scope. (June, 1944.)

Summary of standards and requirements for *U.S. Housing Authority*—aided projects. (1940.)

Federal Public Housing Authority Circular 1–4–44. Sound reduction; and *Supplement No.* 1. Structural design. (1944.)

FEDERAL HOUSING ADMINISTRATION

Technical Bulletin No. 2.—Modern design. (1941.) 5 cents.

Technical Bulletin No. 3.—Contract documents for small house construction. (March, 1941.) 5 cents.

Technical Bulletin No. 4.—Principles of planning small houses. (Revised, July, 1940.) 10 cents.

Technical Bulletin No. 5.—Planning neighbourhoods for small houses. (Revised, July, 1938.)

Technical Bulletin No. 6.—Mechanical equipment for the home. (February, 1937.)

Technical Bulletin No. 7.—Planning profitable neighbourhoods. (1938.) 20 cents.

[The above are published by U.S. Government Printing Office.]

7th Annual Report of the Federal Housing Administration. (1941.)

Underwriting Manual. (1938.)

Minimum requirements for rental housing projects; submitted under Title VI. Section 608. National Housing Act. Effective May 26th, 1942.

FEDERAL PUBLIC HOUSING AUTHORITY

Aluminum City terrace housing. Pittsburgh (East Kensington) Pa.

U.S. DEPARTMENT OF THE INTERIOR. (BONNEVILLE POWER ADMINISTRATION)

Feasibility study for converting 200 permanent type homes in Fourth Plain Village, Washington, from coal heat to electric heat. (Prepared by *Commercial Operations Section of Power Management Division*, November, 1943.)

Utilisation Paper No. 5.—Heating rural and urban dwellings with electrical energy: *G. H. Bliesner* and *H. E. Bixby*. (April, 1941.)

CLEVELAND METROPOLITAN HOUSING AUTHORITY

Community recreation in Cleveland Housing Estates: *F. E. Connelly* and *G. P. Bauer*. (Reprinted from "*Recreation*", October, 1940.)
Low rent housing.
Cleveland's public housing estates.
Woodhill Homes—low rent housing estate.
Cedar central apartments.
Lake Shore Village homes for war workers.

REGIONAL ASSOCIATION OF CLEVELAND PUBLICATION

No. 3.—An analysis of a slum area in Cleveland: *R. B. Navin*. (November, 1939.)

PRESIDENT'S CONFERENCE ON HOME BUILDING, ETC.

Seven volumes of proceedings. (Washington, D.C., 1932.)

BETTER HOMES IN AMERICA

Home Information Service, 1936–37.
No. 10/11.—Description and cost analysis of a steel house.
No. 19/20.—Prefabricated house.
No. 21/22.—Low cost house.
No. 28.—Safe sewage disposal for rural houses.
No. 30.—Good lighting in houses.
No. 31.—Planning the small house.
No. 32.—Planning the arrangement of furniture.
Choosing a site for a new home: *R. B. Hull.*

REVERE COPPER AND BRASS, INC.

The house you live in.
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Apartment homes for to-morrow's better living.

ARCHITECTURAL RECORD

Housing from the tenant's viewpoint. A summary of a voluminous report by *E. Coit*. (Reprinted from "*Architectural Record*", April, 1942, 71–84.)

(*b*) *Canada.*

ADVISORY COMMITTEE ON RECONSTRUCTION

IV. Housing and community planning. Final report of the Sub-committee. (March, 1944.)

NATIONAL HOUSING ACT, 1944

Text. (1945.)
Memorandum specifications covering minimum standards of materials and construction to be used to . . .
The Canada Gazette, 1945, *79* (4). 3rd February, 1945. Regulations.

DOMINION HOUSING ACT

Architectural competition : low-cost house designs.
Model house designs.

DOMINION BUREAU OF STATISTICS

Housing schedule, Form 4. Questionnaire.
Releases. Preliminary Housing Nos. 1–36.
Releases. Preliminary Housing No. MB.–1.
Releases. Preliminary Housing No. D–1 to D–7.

NATIONAL RESEARCH COUNCIL

No. 859. Model Zoning by-law.

CONSUMER'S GAS COMPANY, TORONTO

Rate " A " optional domestic water heating, refrigerator or house heating rate.

BUREAU OF MUNICIPAL RESEARCH, TORONTO

White Paper No. 226.—Open letter on the housing bye-law.
White Paper No. 236.—A home-owning citizenship.
White Paper No. 275.—Metropolitan migration. Story No. 3.
White Paper No. 279.—How Toronto citizens are housed.
White Paper No. 284.—City planning.

8. ATMOSPHERIC POLLUTION.

(*a*) *United States of America.*

BATTELLE MEMORIAL INSTITUTE

Photo-electric smoke recorder. Drawing No. A–449–C.
Photo-electric smoke recorder. Drawing No. M–448–O.

CITY OF ST. LOUIS

Ordinance No. 41804. (Smoke ordinance).
Ordinance No. 42111. (Solid fuel ordinance).
Report of St. Louis Committee on Elimination of Smoke. February 24th, 1940. Second printing, July, 1944.
Record of soot fall for St. Louis. January, 1927.
Number of 3 dollar permits 1939–1944 inclusive.
Heating habits of the people of St. Louis.
Highlights of St. Louis smoke elimination programme. 1944.
Recommendations for smoke elimination in St. Louis. 1940.
St. Louis' winning fight on smoke : " *St. Louis Post-Despatch*," February 2nd, 1941.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Observed performance of some experimental chimneys: *R. S. Dill, P. R. Achenbach* and *J. T. Duck*. (Reprinted from "*Heating, Piping and Air-Conditioning*," 1942).

9. BUILDING MATERIALS, EQUIPMENT AND METHODS OF CONSTRUCTION.

(*a*) *United States of America.*

BI–2. EDUCATION GROUP

Design training for the building industry. 1942.

U.S. DEPARTMENT OF AGRICULTURE, FOREST SERVICE

Forest Products Laboratory in co-operation with the *University of Wisconsin*:— Project L—128—2J5. Problem C—651. Comparative resistance to vapour transmission of commercial building papers: *M. Heinig* and *L. V. Teesdale*. (November, 1938).

FEDERAL HOUSING ADMINISTRATION

Technical Circular No. 1.—Plywood exterior wall finish. (December, 1938).
Technical Circular No. 2.—Protection against termites; good construction, termite barriers, and wood preservation. (1939).
Technical Circular No. 3.—Reinforced concrete construction. (Revised, January, 1943).
Technical Circular No. 4.—Rulings on new methods of construction and determination of acceptability of individual materials. (Revised, November, 1944).
Technical Circular No. 5.—Masonite tempered "Presdwood" exterior wall finish. (December, 1939).
Technical Circular No. 6.—Two-Coat paint systems for exterior use. (February, 1940).
Technical Circular No. 8.—Plank floor and roof construction. (October, 1940).
Technical Circular No. 9.—Special methods of house construction: a discussion of recent developments in dwelling construction and a list of materials and methods of construction. (May, 1942).

[The above Circulars are neo-typed documents.]

Technical Bulletin No. 1.—Recent developments in dwelling construction. (Revised, July, 1940).

[Printed and published by U.S. Government Printing Office. 5 cents. each.]

U.S. DEPARTMENT OF COMMERCE, NATIONAL BUREAU OF STANDARDS

Report B.M.S. 74.—Structural and heat-transfer properties of U.S.S. Panelbilt prefabricated sheet-steel constructions for walls, partitions and roofs sponsored by the Tennessee Coal, Iron and Railroad Co.: *H. L. Whittemore, A. H. Stang, V. B. Phelan* and *R. S. Dill*. (June, 1941).

Report B.M.S. 90.—Structural properties of "P.H.C." prefabricated wood-frame constructions for walls, floors and roofs, sponsored by the P.H.C. Housing Corporation: *M. F. Peck*, *W. G. Hoback* and *V. B. Phelan*. (August, 1942).

[The above are published by U.S. Government Printing Office. 15 cents.each.]

NATIONAL BOARD OF FIRE UNDERWRITERS

Bulletin of Research No. 32.—Fire hazard classification of building materials. (September, 1944).

PRACTICAL BUILDER

Market plant issue for the building industry. (January, 1945).

UNIVERSITY OF MINNESOTA

Institute of Technology Bulletin No. 22.—Vapour transmission analysis of structural insulating board: *F. B. Rowley* and *C. E. Lund*. (October, 1944).

Engineering Experiment Station Bulletin No. 17.—Methods of moisture control and their application to building construction: *F. B. Rowley*, *A. B. Algren* and *C. E. Lund*. (April, 1940).

Engineering Experiment Station Bulletin No. 18.—Condensation of moisture and its relation to building construction and operation: *F. B. Rowley*, *A. B. Algren* and *C. E. Lund*. (September, 1941).

BETTER HOMES IN AMERICA

Home Information Service, 1936–37

No. 8.—Walls and wall treatments.
No. 9.—Plaster cracks in houses.
No. 12.—Dry cellars.
No. 14/15.—Wood frame and stucco house.
No. 17/18.—All-wood house.
No. 23/24.—Reinforced concrete house.

(*b*) *Canada.*

NATIONAL RESEARCH COUNCIL

No. 900.—The permeability of water vapour through building materials.

10. MISCELLANEOUS REPORTS, ETC.

(*a*) *United States of America.*

AMERICAN GAS ASSOCIATION

List of publications, 1944.

JOHN B. PIERCE FOUNDATION

Physiological influence of atmospheric humidity: *C. E. A. Winslow.* (Reprinted from A.S.H.V.E. *Trans.*, 1942, *48*)

UNIVERSITY OF ILLINOIS

Publications of the Engineering Experiment Station of the University of Illinois. (July, 1943).

U.S. DEPARTMENT OF THE INTERIOR, BUREAU OF MINES

Guide to Central Experiment Station, Bureau of Mines, 1941.

AMERICAN SOCIETY OF HEATING AND VENTILATING ENGINEERS

Air disinfection in ventilation: *W. F. Wells.* (June, 1944).

Use of glycol vapour for air sterilisation and the control of air-borne infection. (June, 1944).

Study of changes in the temperature and water vapour content of respired air in the nasal cavity.

(*b*) *Canada.*

DEPARTMENT OF MINES, BUREAU OF MINES

No. 777.—Catalogue and index of Mines Branch reports.

NATIONAL RESEARCH COUNCIL

No. 104.—The penetration of water vapour into wood.
No. 690.—Moisture on windows.
No. 725.—Air conditioning. A list of recent books with contents, publishers and prices.

UNIVERSITY OF TORONTO

SCHOOL OF ENGINEERING RESEARCH, FACULTY OF APPLIED SCIENCE AND ENGINEERING

Bulletin 9.—Collection of papers. (1932).

ONTARIO HYDRO-ELECTRIC POWER COMMISSION

Rules and regulations governing electrical installations and equipment. (1939).
Decew Falls, 1943.
Hydro-electricity in Ontario, 1939.
Electric power supply in strategic Ontario.

11. MANUFACTURERS' CATALOGUES.

(*a*) *United States of America.*

(*b*) *Canada.*

The literature collected included a number of manufacturers' catalogues of various fuel burning appliances and accessories.

ADDENDUM TO LIST OF LITERATURE

APPENDIX No. 6

AMERICAN GAS ASSOCIATION

1.—Approval Requirements for Domestic Gas Ranges. January 1st, 1941.

2.—Listing Requirements for Attachable Gas Water Heating Units. January 1st, 1942.

3.—Listing Requirements for Relief and Automatic Gas Shut-off Valves for Use on Water Heating Systems. January 1st, 1936.

4.—Listing Requirements for Draft Hoods. January 1st, 1938.

5.—Approval Requirements for Hotel and Restaurant Deep Fat Fryers. January 1st, 1941.

6.—Listing Requirements for Attachable Gas Water Heating Units without Water-Carrying Parts. January 1st, 1939.

7.—Approval Requirements for Central Heating Gas Appliances. January 1st, 1943.

8.—Listing Requirements for Automatic Pilots. January 1st, 1941.

9.—Approval Requirements for Gas-fired Duct Furnaces. January 1st, 1943.

10.—Requirements and Recommended Practice for House Piping and Appliance Installation. 1940.

11.—Requirements for Official Marking of Approved Gas Appliances and Listed Accessories. July 1st, 1940.

12.—Requirements for Installation of Conversion Burners in House Heating and Water Heating Appliances. 1940.

13.—Approval Requirements for Hot Plates and Laundry Stoves. January 1st, 1941.

14.—Listing Requirements for Automatic Main Gas Control Valves. January 1st, 1936.

15.—Listing Requirements for Semi-Rigid Gas Appliance Tubing and Fittings. January 1st, 1942.

16.—Approval Requirements for Gas Water Heaters. January 1st, 1944.

17.—Approval Requirements for Gas Space Heaters. January 1st, 1941.

18.—Fundamentals of Domestic Gas Water Heating.

INDEX

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POST-WAR BUILDING STUDIES

1. HOUSE CONSTRUCTION. By an Inter-Departmental Committee appointed by the Minister of Health, the Secretary of State for Scotland and the Minister of Works. 2*s.* (2*s.* 3*d.*)
2. STANDARD CONSTRUCTION FOR SCHOOLS. By a Committee appointed by the President of the Board of Education. 6*d.* (7*d.*)
3. PLASTICS. By a Committee convened by The British Plastics Federation. 1*s.* (1*s.* 2*d.*)
4. PLUMBING. By the Plumbing Committee of the Building Research Board of the Department of Scientific and Industrial Research. 1*s.* (1*s.* 2*d.*)
5. THE PAINTING OF BUILDINGS. By a Committee convened by The Paint Research Association. 1*s.* (1*s.* 2*d.*)
6. GAS INSTALLATIONS. By a Committee convened by The Institution of Gas Engineers. 6*d.* (8*d.*)
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9. MECHANICAL INSTALLATIONS. By a Committee convened by The Institution of Mechanical Engineers. 2*s.* (2*s.* 3*d.*)
10. SOLID FUEL INSTALLATIONS. By a Committee convened by the British Coal Utilisation Research Association. 9*d.* (11*d.*)
11. ELECTRICAL INSTALLATIONS. By a Committee convened by The Institution of Electrical Engineers. 1*s.* 6*d.* (1*s.* 8*d.*)
12. THE LIGHTING OF BUILDINGS. By the Lighting Committee of the Building Research Board of the Department of Scientific and Industrial Research. 2*s.* 6*d.* (2*s.* 9*d.*)
13. NON-FERROUS METALS. By a Committee convened by the British Non-Ferrous Metals Research Association. 1*s.* (1*s.* 2*d.*)
14. SOUND INSULATION AND ACOUSTICS. By the Acoustics Committee of the Building Research Board of the Department of Scientific and Industrial Research. 1*s.* (1*s.* 2*d.*)
15. WALLS, FLOORS AND ROOFS. By a Committee convened by the Royal Institute of British Architects. 9*d.* (11*d.*)
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19. HEATING AND VENTILATION OF DWELLINGS. By the Heating and Ventilation Committee of the Building Research Board of the Department of Scientific and Industrial Research. 2*s.* 6*d.* (2*s.* 10*d.*)

*20. FIRE GRADING OF BUILDINGS. By the Fire Grading Committee of the Building Research Board of the Department of Scientific and Industrial Research, and of the Fire Offices' Committee. 1*s.* 6*d.* (1*s.* 8*d.*)

21. SCHOOL BUILDINGS FOR SCOTLAND. By a Committee appointed by the Secretary of State for Scotland. 1*s.* (1*s.* 2*d.*)
22. FARM BUILDINGS FOR SCOTLAND. By a Committee appointed by the Secretary of State for Scotland. 1*s.* 6*d.* (1*s.* 8*d.*)
23. HOUSE CONSTRUCTION. SECOND REPORT (See No. 1 above.) 1*s.* 6*d.* (1*s.* 8*d.*)

*24. SCHOOL FURNITURE AND EQUIPMENT. By a Sub-Committee of the Standard Committee of the Ministry of Works. 6*d.* (7*d.*)

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