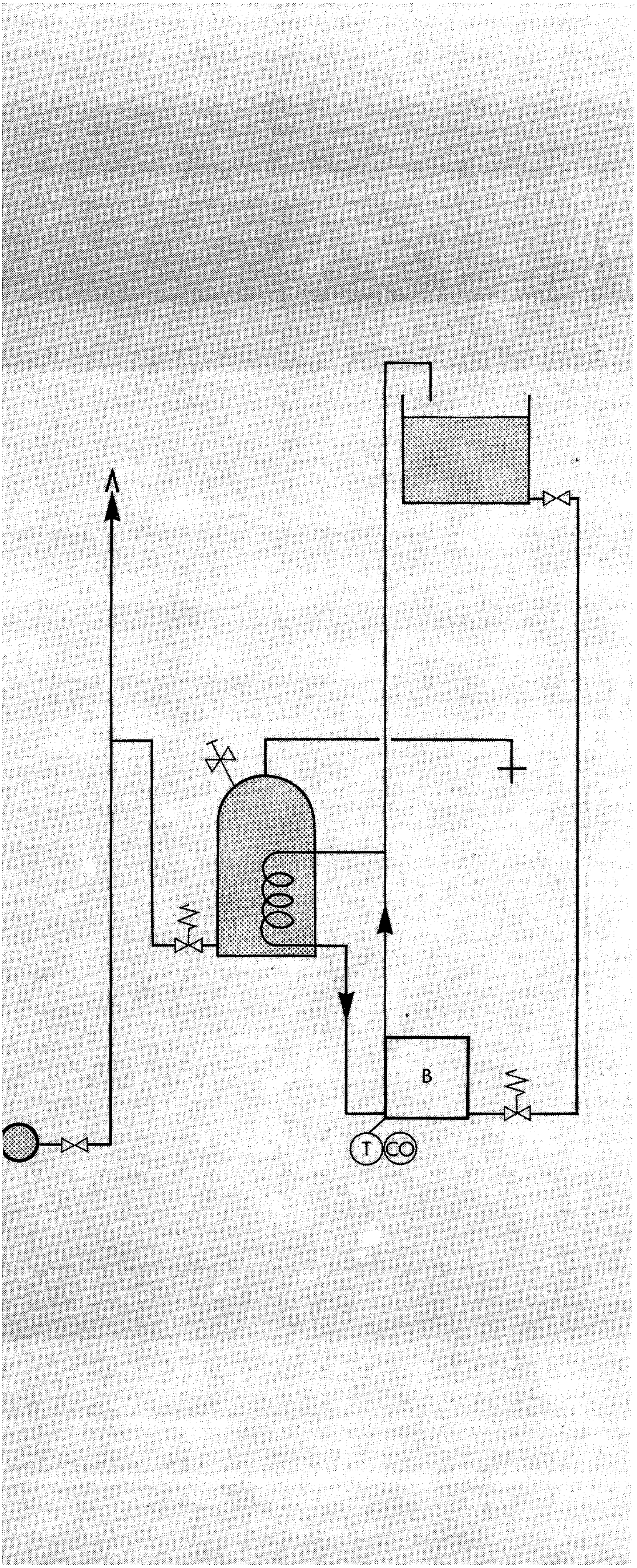
Standing Technical Committee
on Water Regulations

335/11



Domestic Unvented Hot Water Systems

DOE

Department of the Environment
National Water Council

Standing Technical Committee reports
Number 3

Standing Technical Committee
on Water Regulations

The Consequences for the Introduction of Domestic Unvented Hot Water Systems in England and Wales

Copies of this publication are available only from the National Water Council, 1 Queen Anne's Gate, London SW1H 9BT

Department of the Environment
2 Marsham Street, London SW1P 3EB
ISBN 0 904561 17 8
 Price £2.50

Chairman's Foreword

IN MARCH 1975 following consultations between the Department of the Environment, the National Water Council and the Water Authorities, the Standing Technical Committee on Water Regulations was set up to advise on the technical requirements of water byelaws and water regulations.

At the present time, water undertakings' byelaws prohibit the connection of hot water apparatus directly to service pipes (except for instantaneous water heaters). This requirement was established in Great Britain many years ago and led to the development of the present practice of low pressure cistern-fed domestic hot water systems.

In many other countries, no such prohibition exists, on the contrary, many ban the use of storage cisterns on hygienic grounds. Thus practice overseas, particularly on the Continent, differs from that in Great Britain. However, there has been a considerable growth of demand in this country for mains connected water heating apparatus and some relaxations of the byelaws have been made to permit more flexibility. Following the recommendations of the Committee on Backsiphonage in Water Installations that the exclusion of mains connected systems could not be justified on the grounds that it was needed to prevent contamination, the Department undertook a review of the subject.

As a part of that review, it was necessary that minimum byelaw requirements for domestic mains pressurised hot water systems should be considered and the Committee on Pressurised Hot Water and Heating Systems was set up. Its Report on regulatory requirements forms the Appendix to this consultation paper. The recommendations in this Report have been accepted by the Standing Technical Committee as the bases on which mains pressurised hot water and heating systems, if introduced, would be as acceptable as the present system.

Before the Standing Technical Committee gives its advice to the Department and the National Water Council on whether the present prohibition should be retained, removed or relaxed, the Committee wishes to obtain the views of interested bodies and persons likely to be affected. To do so, this consultation paper has been prepared and in it a number of specific questions are asked and evidence is solicited on certain matters. The Committee hopes to make its report on the comments together with its recommendations by mid-1977.

S. F. White,
Chairman
Standing Technical Committee on Water Regulations.

CONTENTS

THE CONSEQUENCES FOR THE INTRODUCTION OF DOMESTIC UNVENTED HOT WATER SYSTEMS IN ENGLAND AND WALES

1. INTRODUCTION

1.01 Traditional British domestic hot water supply in which water is heated and stored for subsequent use is based on cold water feed from a storage cistern to hot water apparatus that is vented to atmosphere. Model byelaw 46[1] prevents hot water apparatus from being connected directly to service pipes and thereby being subject to mains pressure. There are permitted exceptions whereby non-storage fed instantaneous water heaters may be supplied under mains pressure.

1.02 Fig. 1 illustrates a typical system conforming to present byelaws. The supply to cold water taps can be taken either from a cold water cistern or direct from the service pipe. The latter is common practice in the West and North of England. The former is usual, in some cases mandatory, in the South-East. In all dwellings a drinking water tap supplied from the service pipe must be provided. Even in the South-East it is common practice for washing machines to be so connected.

1.03 The justification for Byelaw 46 is that it is a measure to prevent the ingress of hot water into the cold water system. The Backsiphonage Committee[2] devoted a great deal of time to this subject and considered that although such ingress may be undesirable it was not in itself a contamination hazard. The Committee recommended that with suitable precautions the restriction should be relaxed and mains fed hot water supply installations should be permitted in the United Kingdom as an alternative choice to the traditional system.

1.04 The Committee on Pressurised Hot Water and Heating Systems (PHWS Committee) were set up to make recommendations on the precautions which would have to be taken to ensure that mains fed unvented hot water systems would be as safe against bursting hazards as those currently permitted in the United Kingdom. The Committee have now reported and a copy of the report is appended. Their report deals with the possible introduction of the unvented system, principally into single unit dwellings in the UK. The Committee have made it clear that they need to consider further the application of the principles of the report to multi-unit dwellings where numerous households could be supplied with hot water from a large common boiler installation.

Although the report deals principally with those parts of installations from which hot water is drawn off for domestic use there are implications for the design of the heating elements and primary 'boiler' circuits.

The Committee would welcome views on the report particularly in answer to:

(a) Are the recommendations acceptable or should they be modified?

(b) Is it agreed that cistern fed unvented hot water appliances[3] at present permitted under the byelaws should be specifically covered in regulations?

1. Throughout the report byelaw references are to Model Water Byelaws 1966 Edition. The numbering and in certain respects, the requirements, of the Model Water Byelaws (Scotland) differ.
2. Report of the Committee on Backsiphonage in Water Installations (HMSO 1974).
3. A cistern fed unvented appliance is a water heater or boiler supplied under gravity from a storage cistern, the appliance itself not being vented to atmosphere (see Appendix Cases 2A and 2B).

1.05 The Standing Technical Committee are issuing this consultation paper partly to give a wide circulation to the PHWS Committee's recommendations and partly to obtain a consensus of views about the supplementary action which should be taken before the recommendations of the Backsiphonage Committee could be implemented. The Standing Committee have accepted the report of the PHWS Committee. They wish to make it quite clear at the outset that they consider the traditional storage fed hot water system is generally satisfactory, safe, and reliable and there is no question that the Committee will suggest that it should no longer be commonly used.

The paper sets out some of the factors which appear to be relevant to the possible introduction of the mains fed unvented system and at the end of each section draws attention to specific points on which opinions are sought. The Committee will in due course consider the comments and will report to the Department of the Environment, the Scottish Development Department and the National Water Council with specific recommendations concerning the possible introduction of mains fed unvented systems in the UK. If the Committee decide to take a positive attitude to that introduction, they recognise that timing is of the utmost importance.

1.06 Where comment is particularly requested, text is in bold black type.

2. THE UNVENTED HOT WATER SUPPLY SYSTEM

2.01 The typical Continental hot water supply system is supplied direct from the service pipe and there is usually no cold water feed cistern. The water heater is often of the instantaneous type but indirect heating is becoming more widely used. A pressure relief valve is fitted on the inlet side in association with a check valve.
The PHWS Committee considered how this type of system could be adapted to suit UK conditions. Their recommendations are illustrated in Figs. 2 and 3. Precise descriptions and definitions of the system are given in the report but in outline the precautions recommended for a mains fed unvented hot water storage heater are:

(a) thermostatic control both at the boiler and at the electric immersion heater (if fitted);

(b) temperature energy cut offs both at the boiler and at the electric immersion heater (if fitted);

(c) thermal relief valve designed to limit temperature to a value below 100°C (Recommended 90°C);

(d) pressure relief valve designed to limit pressures to a value at some point above the maximum working pressure likely to be attained. (A pressure relief valve may also be required on the primary circuit if the system is of the closed circuit type.) Their function is to provide against failure to handle expansion water.

(e) an upstand or other means to prevent cylinders from draining down; and

(f) an expansion vessel designed to accommodate expansion of hot water if a check valve or a pressure-reducing valve of the non-back flow type were fitted on the cold inlet. (It would also be necessary to instal means to accommodate expansion water within a sealed primary system.)

The provision of either a thermal relief valve or an expansion vessel is not typical of Continental practice in domestic hot water supply systems. The recommendations of

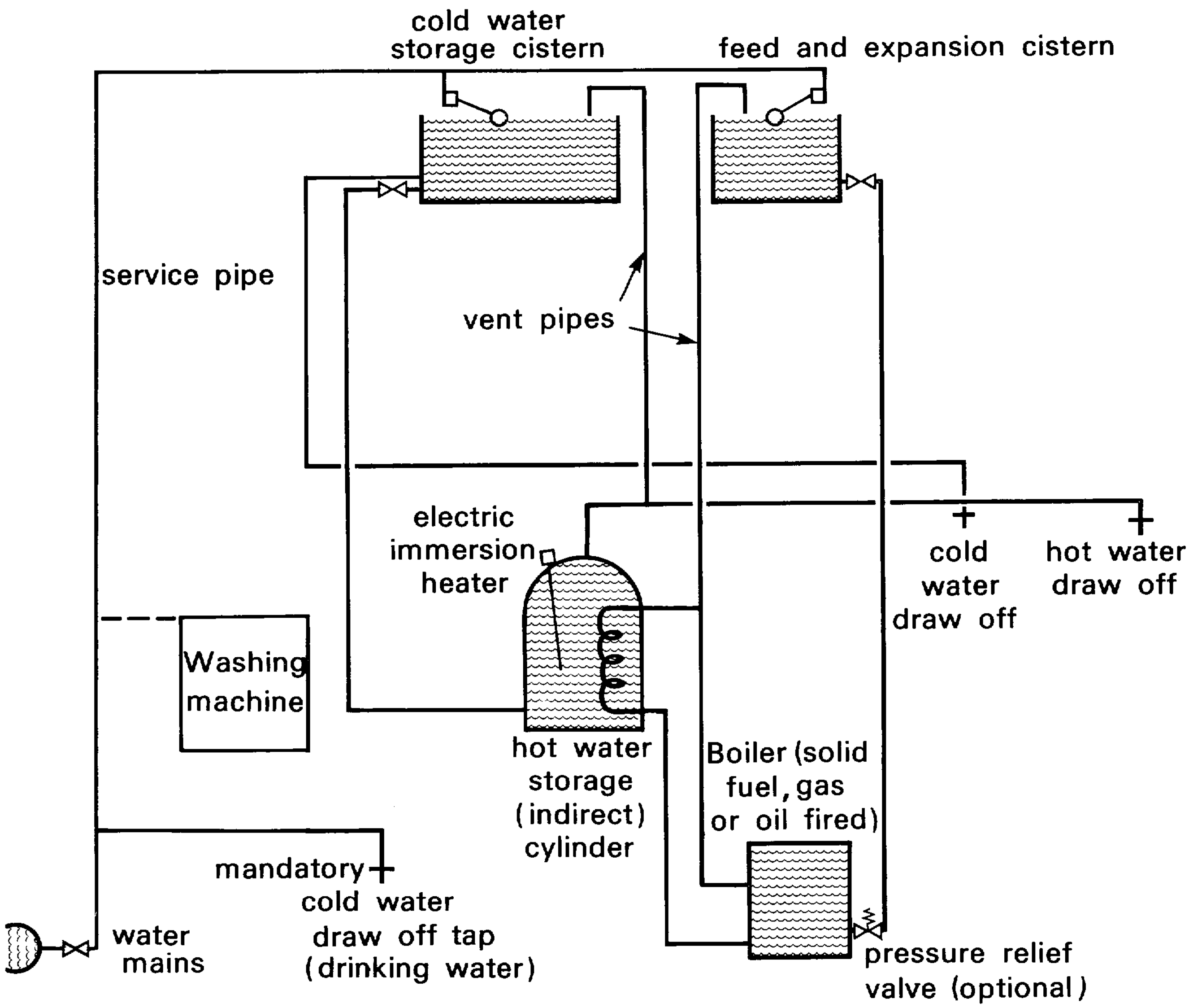


FIG.1 TYPICAL BRITISH DOMESTIC WATER INSTALLATION

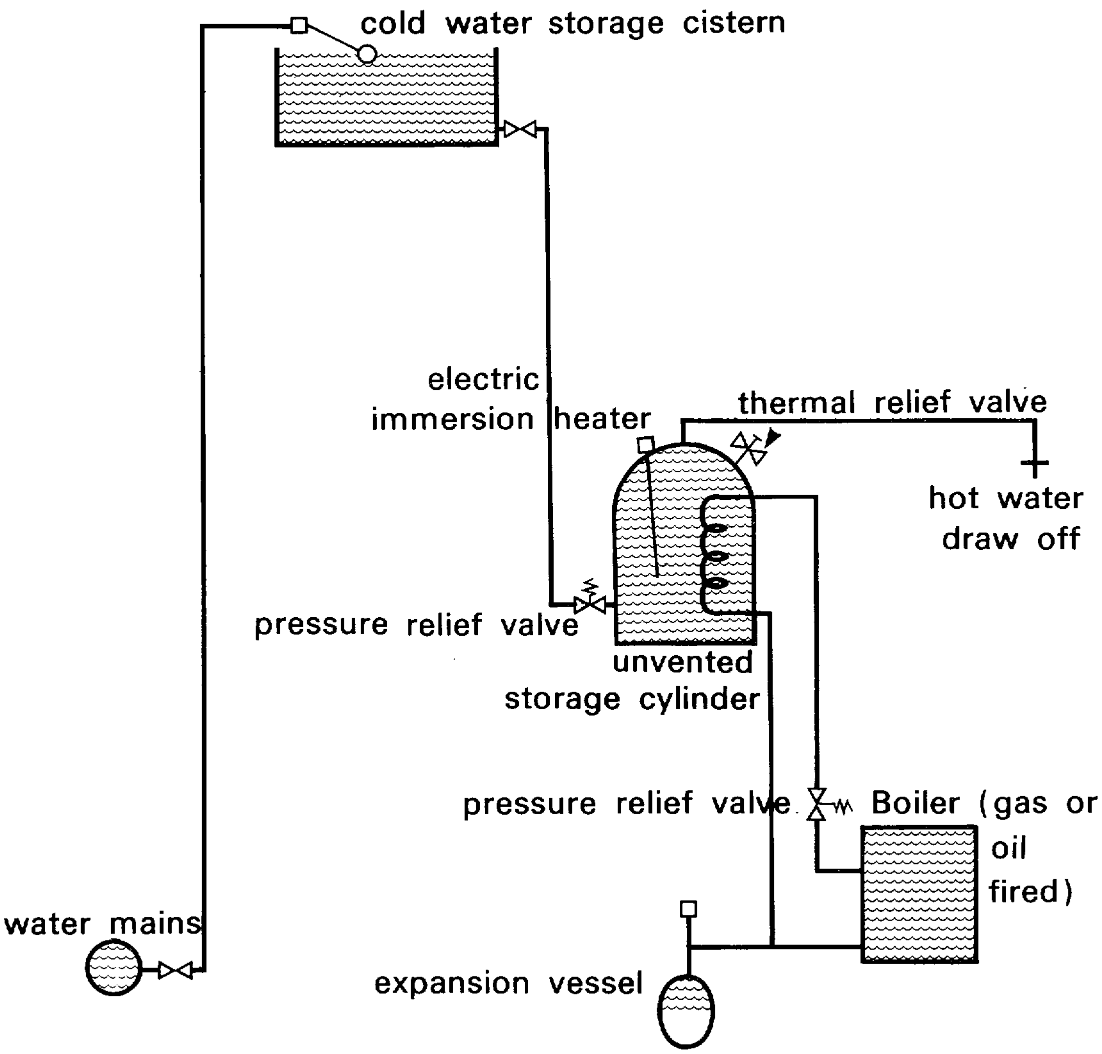


FIG.2 CISTERN FED UNVENTED DOMESTIC HOT WATER STORAGE SYSTEM (sealed primary circuit)

Note:- at the present time there are no byelaw requirements for the provision of a pressure relief valve, a thermal relief valve, or an expansion vessel. The precautions shown are those recommended by the P.H.W.S. committee

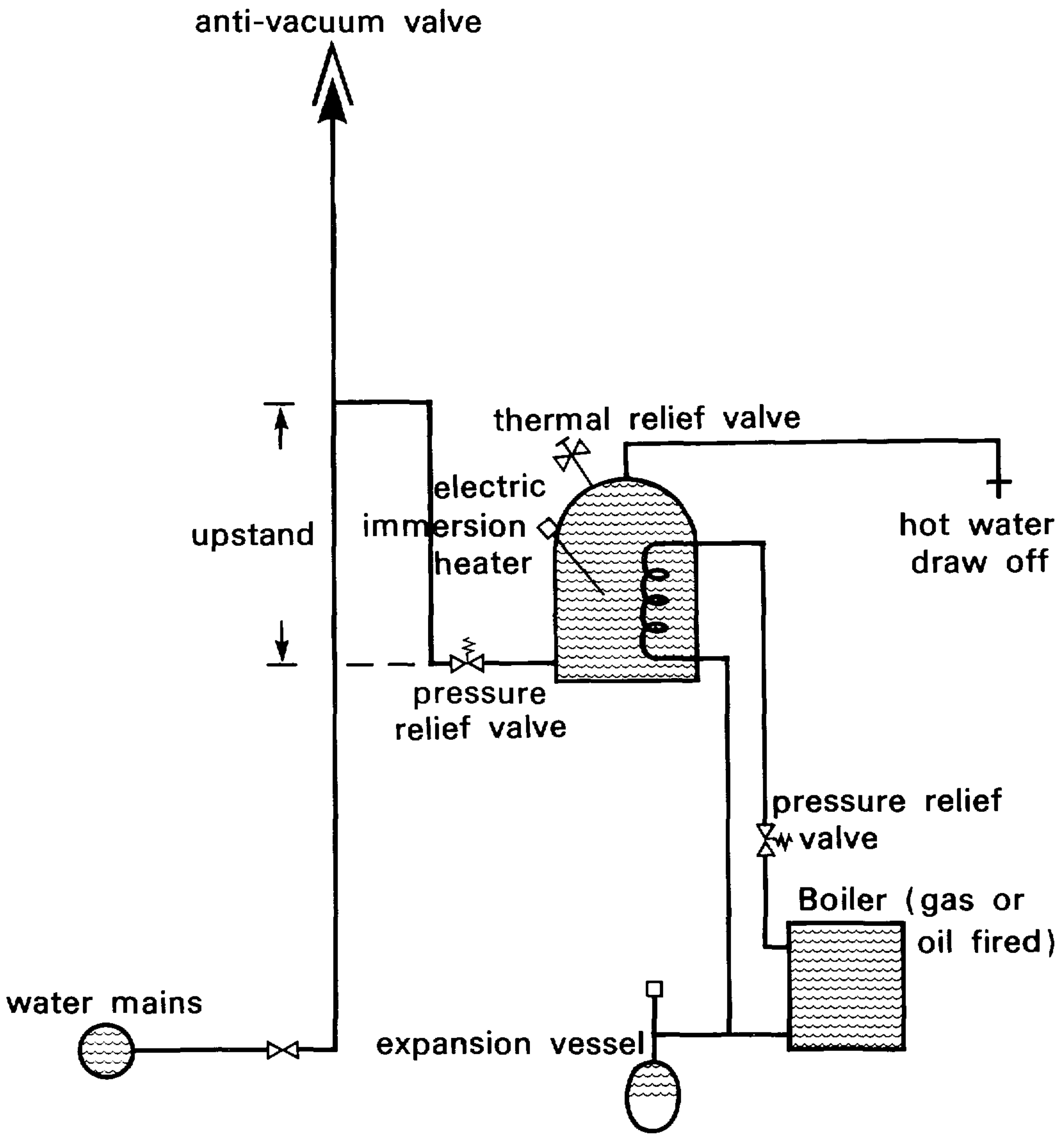
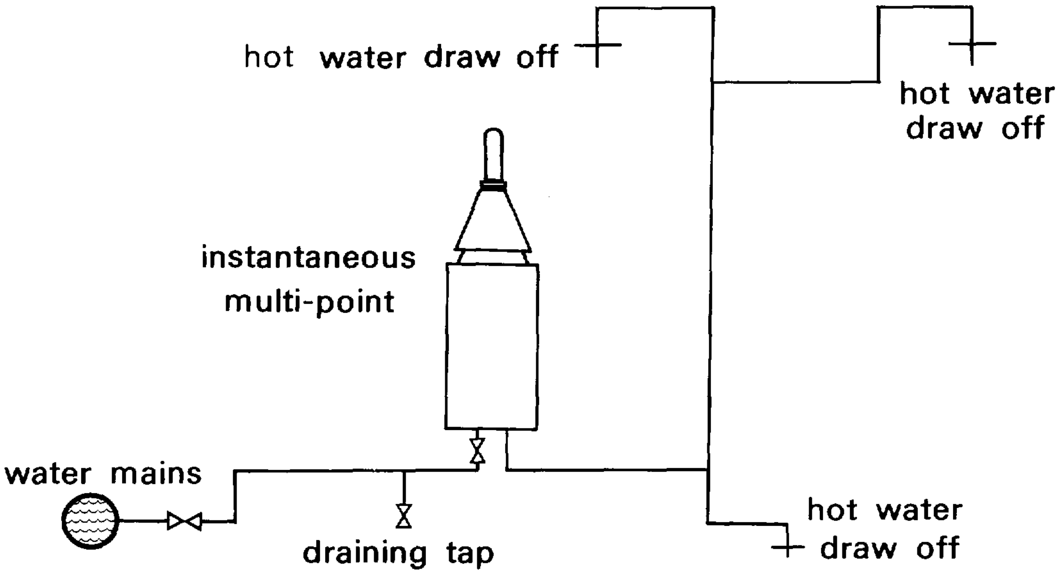


FIG.3 MAINS FED UNVENTED DOMESTIC HOT WATER STORAGE SYSTEM (sealed primary circuit)

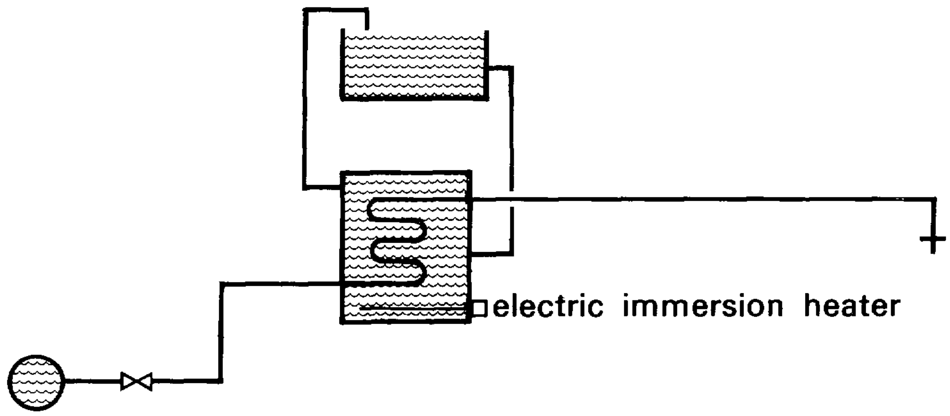
Note:- the precautions shown are those recommended by the P.H.W.S. committee.
Some of these are mandatory on the Continent.
The combination shown of anti-vacuum valve and upstand is required to prevent the water heater from draining down; similar protection can be afforded in other ways

A. CISTERN FED UNVENTED HOT WATER STORAGE AND SEALED PRIMARY CIRCUITS – SEE FIG.2 including Note

B. INSTANTANEOUS WATER HEATERS



C. WATER JACKETED TUBE HEATERS



D. MAINS FED STORAGE HEATERS (each up to 68 litres)

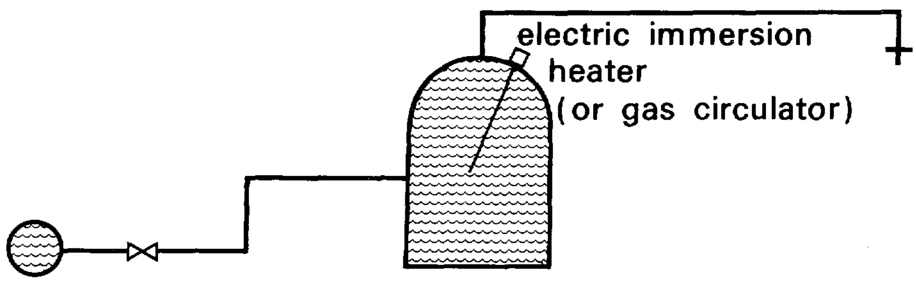


FIG.4 EXAMPLES OF UNVENTED HOT WATER APPARATUS WHICH COMPLY WITH THE MODEL WATER BYELAWS

the Committee apply also to installations such as those indicated in Fig. 4 which appear to comply with the model water byelaws.

2.02 A demand for a variation of the unvented system could arise in multi-storey, multi-occupancy dwellings where it is desired to serve several storeys from one cistern. To avoid a multiplicity of vent pipes, a system such as that indicated in the PHWS Committee Report Case 6 might be wanted. The PHWS Committee have considered such cases and recommend similar precautions to those set out in 2.01 above.

It is as well to emphasise that at present such systems can be installed without a requirement for provision of pressure relief, thermal relief valves, or expansion vessels. Here again, each primary circuit could require a pressure relief valve.

2.03 Should mains fed unvented systems be permitted in the UK, the Committee consider the PHWS Committee recommendations form a suitable basis for appropriate regulations. This consultation paper is concerned only with the consequences of the introduction of such systems. It is not concerned with the design of such systems.

3. REASONS FOR CONSIDERING THE INTRODUCTION OF THE UNVENTED HOT WATER SUPPLY SYSTEM

3.01 The present storage-fed hot water supply system in the UK in general gives satisfaction and if constructed in accordance with the byelaws is safe. It is not known how widely mains fed unvented hot water systems, if permitted, would be adopted in the UK but the determining factor would almost certainly be cost. Savings in fittings, distribution pipes and cisterns afforded by the unvented system could be offset by the additional cost of stronger storage cylinders, larger service pipes, and the need for relatively expensive thermal and pressure relief valves and, in some cases, pressure reducing valves. Maintenance of the mains fed system could be more expensive and skilled.

3.02 Higher pressures at terminal fittings would permit the use of smaller, cheaper and often more attractive draw off taps and mixer taps. At the moment many are being imported and fitted despite their higher resistance to flow and British manufacturers have complained about these imports. Such fittings do not necessarily contravene the present byelaws even though they may not give adequate flows.

Also, there is a consumer demand for higher pressures at shower fittings. Showers are considered to be economical in use of water and energy. Cistern fed units often give inadequate flows. The introduction of mains fed unvented hot water systems would enable the demand for the use of these fittings to be met in properly designed installations.

3.03 The recommendations of the PHWS committee cover instantaneous and other mains fed hot water apparatus which are at present permitted under Byelaw 46 (see Fig. 4). The Committee recommend precautions which, if they were implemented, would require substantial modification of this byelaw.

At present a limited amount of heated water (up to 14 litres) can be held under mains pressure without any prescribed safety device or other form of relief valve. Further, up to 68 litres may be held providing the heater is fitted with an 'efficient device' which will prevent the siphonage back through the inlet or limit the quantity siphoned back on any one occasion to not more than 20% of the capacity of the heater (Model Byelaw 46(c))[4]. The interpretation of this byelaw has given difficulty and if the PHWS Committee recommendations are accepted for these categories of apparatus it is logical to consider the extension to other categories of apparatus.

3.04 It is perhaps in the multi-occupancy building that there is the greatest demand for change. At present these dwellings can be supplied either from a number of cold water feed cisterns (at each dwelling unit) or from a common cistern or cisterns, each at a level suitable to serve a number of dwellings. In many cases difficulty is experienced in locating cisterns at sufficient height in individual dwelling units to give adequate flows to certain fittings, particularly showers.

The present byelaws are not designed to meet the conditions met in such buildings and expensive measures may have to be taken to enable a design to conform in principle. The ability to use unvented systems could give flexibility to the designer and installer and potential for economy without loss of performance.

3.05 In some designs of dwellings a significant expenditure is incurred in accommodating a cold water storage cistern and designers would prefer to have the flexibility which a choice of approved systems would allow.

4. CONSEQUENCES FOR CONTAMINATION OF WATER

4.01 The Backsiphonage Committee considered that water which had been heated was not of itself a contamination hazard but it would be necessary to take precautions in the design of installations to prevent backflow of hot water from adversely affecting cold water systems.

4.02 In certain hot water installations which comply with the water byelaws up to about 14 litres of heated water could flow back into the cold water system should there be, for example, a mains burst or a mains shut off for waste metering operations. This quantity can be compared with the volume of expansion water, about 2.5 litres, derived from heating 135 litres of water from 5°C to 65°C. If the pipes between the heater (cylinder) and the junction of the hot and cold feed pipework were able to accommodate this volume, no warm water could be drawn off at a cold tap. Of course, expansion could be accommodated in other ways and the PHWS Committee report deals with these but it does not seem that it would be difficult or expensive to design an installation to avoid warm water problems in the cold water system.

4.03 Freedom from risk of contamination arising from the backflow of used water at points of use can only be assured if the precautions recommended by the Backsiphonage Committee are adopted. These precautions apply also to mains fed cold water installations which are now permitted. From the point of view of the water undertaker although there would be a greater number of mains fed draw off points there should be no additional risk to the mains system. The elimination of the storage cistern would make the installation less accessible for the addition of additives and therefore marginally safer for the occupants of the house.

4.04 The Committee would welcome comments and evidence which would help them to advise on any regulations considered necessary to avoid contamination of water up to the point of use.

4. Model Water Byelaws (Scotland) differ in that they do not prescribe a limitation on the quantity siphoned back.

5. CONSEQUENCES FOR PREVENTION OF WASTE MISUSE AND UNDUE CONSUMPTION OF WATER

5.01 The introduction of mains fed unvented hot water systems could involve three potential sources of waste, misuse or undue consumption of water.

(a) *Leakage from pressure and thermal relief valves.*
In the system proposed by the PHWS Committee expansion would be taken care of either by the use of an expansion vessel or by expansion by backflow against mains pressure. Waste would occur only when either the heater energy cut-out had failed and the thermal relief valve came into operation or when the pressure relief valve had been incorrectly adjusted to a setting below maximum mains pressure.

(b) *Failure of plastic pipes affected by hot water.*
In a storage fed hot water system there is virtually no risk of hot water gaining entry into the cold water system providing there are no unauthorised cross connections. In the mains fed system a certain amount of water could backflow under mains vacuum conditions into the service pipe but only when measures to prevent such backflow had not been taken. (Note remarks under para 3.03). The volume might be sufficient to damage the service pipe if made of certain grades of plastics.

(c) *Greater extent of leakage from the hot water system because of the higher pressure.*
The rate of flow of water to waste from unrepaired dripping hot water taps with faulty washers and from leaks in hot water pipework clearly increases with pressure. It may not be unreasonable to assume that the consumer's tolerance is related to the quantity of flow and not to the pressure within the pipe. Thus it could be argued that a consumer would have a fitting repaired at the same point regardless of pressure inside the fitting. However higher pressure could lead to a greater number of incidents unless design and installation practice matched the higher duty.

5.02 There are a number of arguments which could be mustered to show that unvented systems have some, perhaps limited, potential for reducing waste, misuse and undue consumption compared with the storage system. Rather than considering the merits and demerits of the two systems it is more profitable to consider what precautions should be taken to make each system equally reliable.

5.03 The Committee would welcome views about precautions which should be prescribed in water regulations if the unvented system is permitted. They would like to have brought to their attention any potential source of waste in hot water systems (vented or unvented) which are not dealt with under the present byelaws.

6. CONSEQUENCES FOR NOISE IN INSTALLATIONS

6.01 Noise in plumbing may occur principally from:

(a) Reverberation

(b) Turbulent flow in pipes and fittings due to high velocity

(c) Entry (splash) noise or subsequent exit (waste) noise. The principal offenders are flushing and storage cisterns.

(d) Noise external to the plumbing system but transmitted through pipes. For example a noisy washing machine can cause nuisance several rooms away.

6.02 Although byelaws include provisions which require fittings to be so arranged as to avoid reverberation in pipes, there are no byelaws concerned with the other causes of noise.

6.03 In most domestic situations, particularly in one or two storey dwellings, the introduction of mains fed unvented hot water systems would lead to increased available pressure at draw-off points. On the Continent ⅜ inch dia pipework is often used and the head loss through hot water taps is higher than in the United Kingdom, because of the higher available head.

The introduction of the mains fed unvented system could lead to a much wider use of ⅜ inch dia pipework within dwellings in this country and this may have the consequence of turbulent flow and a greater noise in pipework. On the other hand the omission of a storage cistern would remove one potential source of noise and with it a temptation to fit an unauthorised silencer pipe, to certain types of ball valve.

6.04 It would seem that there is the same need for care in design of installations, fittings and equipment, in mains fed unvented systems as for vented systems. Comments are invited by the Committee on the precautions needed to minimise noise in mains fed unvented hot water installations.

7. CONSEQUENCES FOR THE DISTRIBUTION SYSTEM

7.01 There is no national byelaw requirement for cold water storage to be provided in domestic installations although some water authorities have powers to require it. The general principle has been that such storage is needed for the convenience of the consumer in case of an emergency. Storage can be required by the undertaker under S.60 of the Third Schedule of the 1945 Water Act in areas where the levels are higher than 35 ft below the draw off level of the supply service reservoir. By order, the Minister may increase the distance given above so that the provision could cover a wider area. This latter relaxation has only rarely been used. In certain areas storage has a valuable balancing effect; at peak demand periods pressure in the mains may be inadequate to reach the highest levels in ordinary dwellings.

7.02 Mains supplies may be cut off from time to time, perhaps as a result of a burst or pressure may be substantially reduced when water is taken for fire fighting. In these circumstances, the availability of storage of 100–150 litres customarily provided can be useful to the consumer although its value is limited in areas where flushing cisterns are mains fed.

7.03 The Committee would welcome comments and information in answer to the following questions:

(a) What is the extent of areas where pressures are inadequate to ensure mains fed hot water systems would operate reasonably satisfactorily? In these areas are cold water installations mains fed or are they storage fed?

(b) How frequently (on average) is a domestic installation cut-off and what is the average duration of cessation of supply?

(c) In what proportion of events of cut-off of supply is the water undertaker able to give warning?

(d) Is there any evidence of serious difficulty caused to consumers who have only mains fed cold water installations?

(e) What provisions should be made in the regulations to cover any difficulties arising out of the above?

7.04 Where mains pressures are insufficient to supply water into a cold water storage cistern and/or feed cistern at the maximum rate of water use in a property the water level will draw down for the duration of the peak period. In such cases it has been estimated that the peak flow in the service pipe is reduced to as little as half the peak rate of use. In a lower pressure zone the service pipe may have to be increased in size if a consumer wished to install a mains fed hot water system. Evidence given in answer to the questions set out in 7.03 would give some indication of the extent of such zones.

It should be noted that the water undertaker needs freedom to vary pressures in his mains and the designer of hot water systems must be aware of this need and design accordingly. No doubt the number of consumers sensitive to changes in mains pressure would increase.

7.05 In cases where a number of mains fed hot water systems were installed it would be necessary to apply a diversity factor to determine the overall effect on peak mains flow. In most cases water mains are 100mm dia or larger and a relatively large number of properties could be supplied without a significant loss of pressure en-route. The diversity factor from such a number of properties would reduce the above effect on peak flow markedly to the extent that it is doubtful whether a gradual introduction of mains fed hot water systems in existing development would have any noticeable adverse effect. The effect might be greater where numbers of old properties without satisfactory hot water supplies were provided with mains fed hot water systems. Existing properties with joint service pipes could pose problems for designers.

7.06 A major demand for mains fed hot water systems could arise in new housing estates. In such cases the mains distribution systems could be purpose designed. Water undertakers might find that they had to meet marginally higher peak demands but the design peak would be reduced by a diversity factor and by a fall in demand related to the corresponding fall in mains pressure. Research on this point is needed.

7.07 The Committee would welcome comments and evidence particularly on the following points:

(a) Is there any evidence that design and cost of mains distribution systems in the north and west of the country, where cold water installations are principally mains fed differ significantly from those in the south-east?

(b) Is there any evidence that housing estate mains systems will need to be designed on different bases?

(c) Is there any evidence that the ratio of peak to average flow differs significantly when like is being compared with like in (a) above?

(d) **Is there any evidence that greater provision of service reservoir or booster fed capacity is made?**

(e) **Is there any need for joint communication pipes to be dealt with specifically in the byelaws?**

8. CONSEQUENCES FOR UNITED KINGDOM MANUFACTURERS

8.01 Manufacturers concerned with products suitable for use with cistern fed installations have different interests to those manufacturers whose products are suitable for use with mains pressures. The extent of the effect on a manufacturer of a product suitable only for use in cistern fed installations would depend upon the growth in popularity of mains fed installations. No one can predict this or the speed at which practice might change. Much would depend on the availability of appliances suitable for mains pressures and the ability of installers to cope with changed practice.

8.02 One may assume that demand for cold water storage cisterns would be reduced. At the present time, most are now made of non-metallic materials; in recent years, plastics have replaced much galvanised steel in cisterns. Most hot water storage cylinders are made of copper but mains pressurised unvented cylinders are more likely to be made of other materials unless pressure reducing valves are used.

8.03 Combination tap assemblies are popular with domestic consumers. These fittings are hot and cold water taps coupled together with a common nozzle so as to discharge hot, cold or mixed hot and cold water. Also popular are mixing valves of varying degrees of sophistication ranging from manual operation by a single control to automatic compensating or thermostatic types. Fittings such as these would find a wider field of use in installations supplied direct from the mains; the availability of suitable balanced pressures under mains supply would no doubt see a substantial market for fittings smaller and relatively cheaper than those used in cistern fed installations.

8.04 There could be a substantial demand for 'new' water fittings such as pressure reducing valves, thermal and pressure relief valves and anti-vacuum valves designed both for the United Kingdom and overseas markets in domestic hot water supply.

8.05 The speed of introduction of domestic unvented hot water storage systems will depend upon the availability of suitable fittings and appliances. Continental and American manufacturers meet the demand for such products against standards accepted in their countries. Such standards may not necessarily equate with the standards likely to be adopted in the United Kingdom. However, their designs may be readily adaptable to meet 'approved' status in this country; British manufacturers may therefore be at a disadvantage. There is need not only for ample warning of changes to be given but also for early and firm advice concerning the likely specification of the duties their products will have to meet. The assurance of an adequately based home market may enable British manufacturers to take advantage of the potential of these products for export.

8.06 The Committee would welcome comments and evidence on the following points:

(a) **What is the likely rate of growth in demand for mains fed unvented hot water storage heaters?**

(b) **What are the prior requirements which British manufacturers consider must be met before they develop appliances and fittings for use in these systems?**

(c) **Is there an increasing demand from consumers for combination taps and mixing valves?**

9. PRIOR REQUIREMENTS

9.01 Before hot water apparatus can be permitted to be connected directly to the mains, there are a number of pre-requisites.

(a) A new set of water regulations or byelaws will be needed.

(b) Guidance for good design and practice. In cases of substantial multi-occupation dwellings, such as blocks of flats, there is ample experience amongst qualified designers and there is considerable published material on which to draw. The first need is a code of practice for UK conditions, suitable for modest yet robust systems appropriate in the domestic or single unit dwelling situation.

(c) Standards for performance and test criteria. The first task is the development of criteria and test methods whereby products may be type approved. These criteria will involve two aspects:

i. prevention of contamination or waste of water, and

ii. reliability of safety devices.

British and European Standards are needed so that 'deemed-to-satisfy' status can be afforded in regulations for the convenience of manufacturers, users and enforcement authorities.

(d) Availability of fittings and appliances. There is nothing particularly new about any of the necessary fittings or appliances. Both pressure reducing and pressure relief valves are available and tested for the larger installations but these are not generally suitable for the domestic market. Once British manufacturers are convinced that hot water apparatus will be permitted to be connected directly to the mains, albeit at a date several years hence, they will be in a position to take action to meet the potential market in good time.

(e) Testing fittings and appliances. The National Water Council is considering proposals for a scheme for assessing and testing water fittings; such a scheme might be able to take on the necessary role in testing and possibly supervising systems of quality assurance of the 'self-certification' type.

(f) Training of installation staff and inspectors of enforcement authorities. Although the likely domestic installations should be straightforward to install, the devices used to ensure safety require careful attention not only at the time of initial installation but subsequently by regular inspection and servicing. However, these installations would be no more complex or liable to failure than the present devices on a typical modern gas or oil fired boiler installation. Installers would have to arrange for the instruction of their employees. Similarly, arrangements would have to be made for the training of a number of inspectors of enforcement authorities. It would be helpful if the enforcement authority were able to recognise and accept certificates of certain classes of installers as meeting the enforcement requirements.

9.02 None of these pre-requisites present insuperable problems, but the system adopted for 'approvals' cannot be determined in isolation from arrangements which may be made under the Water Act 1973 or by the Department for building regulations under Part III of the Health and Safety at Work etc Act 1974. When more is known, the system of enforcement necessary will have to be examined in depth. If it is decided to implement the recommendations of the Committee on Backsiphonage in Water Installations that with suitable protection, fully pressurised installations should be permitted in the United Kingdom, a timetable of action will be drawn up.

9.03 The Committee would welcome comment on any of the foregoing matters and on any other matter relevant to the introduction of mains fed unvented hot water systems.

S F White (Chairman)	Directorate General Water Engineering, Department of the Environment
J S W Bath	National Water Council
R Y Bromell	Severn Trent Water Authority
Professor P Burberry	Royal Institute of British Architects
Dr N P Burman	Thames Water Authority
Dr R H G Charles	Department of Health and Social Security
P D Crowther	National Brassfoundry Association
L H C Evans	Property Services Agency, Department of the Environment
W Firth	The Copper Tube Fittings Manufacturers Association and The British Non-Ferrous Metals Federation
D A Gill	Water Research Centre
D G Gamblin	Welsh National Water Development Authority
E Haslam	Worshipful Company of Plumbers
B A O Hewett	Southern Water Authority
E H LeMay	Confederation of British Industries
G Little	Scottish Water Association
R McGillivray	Scottish Development Department
D A Miles	Building Regulations Professional Division, Department of the Environment
F Needham Green	Water Companies Association
R A Pepper	Water Companies Association
J S Pocock	Thames Water Authority
J Reid	North West Water Authority
J Sandor	Department of Prices and Consumer Protection
G F Sizer	British Standards Institution
R B Tabor	Thames Water Authority
H S Tricker	National Water Council
A Watts	Institute of Plumbing

C J D Webster	Building Research Establishment, Department of the Environment
P H Young	British Plastics Federation
E F Young (Secretary)	Directorate General Water Engineering, Department of the Environment

APPENDIX

UNVENTED WATER HEATING INSTALLATIONS IN DWELLINGS

SAFETY MEASURES

Report by the Committee on Pressurised Hot Water and Heating Systems

MARCH 1976

FOREWORD

To: The Chairman
Standing Technical Committee
on Water Regulations

Sir

1. We submit our report in which we advise on reasonable measures for safety of pressurised (unvented) water heating appliances and systems in dwelling.

2. We have taken pressurised water heating appliances to include all types of water heaters providing hot water for use which are not fitted with vent pipes open to atmosphere.

3. Our concern has been to identify safety measures to prevent unvented water heating appliances and systems from bursting as a result of the production of steam under pressure and expansion of water when it is heated.

4. Some of our members have examined installations in this country (under PSA, DOE) as well as in France, Germany, the USA, Australia and New Zealand where mains pressurised unvented water heating has been accepted practice for many years. We have examined information on the causes of bursting in these systems and we are satisfied that provided basic safety principles are observed and safety devices are installed correctly, unvented systems are satisfactory for domestic hot water supply.

5. One of our members has attended several meetings of a joint working group formed of representatives from France, West Germany and Holland as well as this country which has been concerned with harmonisation of safety requirements for mains fed hot water supply systems. On one occasion, a meeting was held jointly with our Committee to discuss particular aspects concerned with the use of check valves to prevent backflow of expansion water.

6. Our Committee has met on 17 occasions over a period of 3 years. In January 1975 we prepared a 'Progress Statement' which outlined our proposals for safety in unvented hot water systems. Copies of this statement were issued to Water Authorities, the Water Companies Association, to professional and technical bodies and to manufacturers' associations; all were invited to submit comments to the Committee. Relevant comments were considered by the Committee and have been borne in mind in producing this Report. The consensus of comments indicated that our proposals were acceptable. Some water industry comments expressed concern at consequential problems which might arise for the water industry. These include possible increase in water use and aspects of maintenance of continuous supplies at adequate pressures in mains to assure satisfactory performance of mains pressurised unvented hot water systems. We feel that these matters, which are of an operational nature, should be capable of analysis and resolution.

7. We have not attempted any studies of the economics of various alternative

systems of domestic hot water supply, as such are outside our terms of reference. If domestic consumers are permitted to have a free choice between vented and unvented systems, costs will be the relevant factor in particular applications. Although we foresee no rapid adoption of unvented storage water heaters either in existing or in new dwellings we expect that costs could fall over a number of years as larger numbers are used.

8. The present Model Water Byelaws (1966 Edition: MHLG) permit specified types of hot water apparatus to be connected directly to service pipes under mains pressures. In effect, these are only instantaneous gas and electric water heaters although storage water heaters capable of holding up to 3 gallons could be permitted. We consider that no action needs to be taken on safety grounds to modify existing mains pressurised heaters providing they conform with the water byelaws.

9. We are aware that sealed (pressurised) systems for domestic central heating have been installed in recent years. We consider that action should be taken to review safety measures in respect of those installations which provide hot water for use through vented indirect cylinders.

10. We make no recommendations concerning the need to prevent safety devices such as pressure and thermal relief valves from freezing up, as might occur in unoccupied dwellings. Nor do we discuss such matters as noise in unvented installations and the need to locate hot and cold pipework so as to prevent cold water supplies from becoming warm which might lead to waste of water or the consequences of the use of chemical additives. We consider these are matters best dealt with either in future water byelaws or in codes of practice.

11. There might be need to consider measures to ensure that toxic chemical additives within unvented primary circuits cannot gain access to secondary and mains systems. Contamination could occur as a result of failure at an interface between an unvented primary circuit and an associated secondary or mains system. This possibility would be increased if a primary circuit operated at a pressure equal to or above that of the secondary or mains system.

12. In conclusion, we are confident that if our recommendations are implemented, the safety record of unvented hot water systems in dwellings will prove to be equal, if not superior, to the record in those other countries which have permitted such installations for many years and which they now consider to be excellent.

Membership and Terms of Reference

The Pressurised Hot Water (PHWS) Committee was formed in May 1973 with the following terms of reference:

1. To consider and report to the Tripartite Briefing Committee on safety measures to deal with aspects such as expansion, pressure relief and temperature of water in pressurised hot water and heating systems primarily in the home but to review also those not covered by the Factories Acts.
2. To consult with interested bodies in the UK and if necessary overseas.
3. To brief and advise one of its members as the delegate to the sub-group of the Tripartite Working Group.

4. To advise the Tripartite Working Group members on specific issues as and when they arise.
5. To advise the Department of the Environment via the Briefing Committee of specific measures which the Committee consider necessary should be adopted in installations in the UK.

Membership of the Committee has been as follows:

Mr E Haslam (Chairman)	Donald Rudd and Partners
Mr C J E Barton	Health and Safety Executive (formerly Department of Employment)
Cdr J S W Bath	National Water Council
Mr M R Bowley (from 12 February 1974 up to 31 December 1975)	PSA, DOE
Mr A A Cornell (from 1 January 1976)	PSA, DOE
Mr L E O'Connell	PSA, DOE
Mr J S Pocock (from 25 June 1975)	Thames Water Authority
Mr J V Sutton	British Gas Corporation
Mr C J D Webster	BRE, DOE
Mr E F Young (Technical Secretary)	DGWE, DOE
Mr A G Alton (Assistant Technical Secretary) (from 28 May 1974)	DGWE, DOE

Papers have been copied to:

Fire Service Inspectorate, Home Office, (Mr W J Carvin)

Department of Industry (Mr H Grunwald)

Department of Prices and Consumer Protection (Mr J Sandor)

Signed

E Haslam (Chairman)

C J E Barton

J S W Bath

A A Cornell

J S Pocock

J V Sutton

C J D Webster

E F Young (Technical Secretary)

CONTENTS

1 INTRODUCTION

1.01 The Report of the Committee on Backsiphonage in Water Installations (HMSO 1974) included a recommendation that with suitable protection, fully pressurised* installations should be permitted in dwellings in the United Kingdom. It noted that if this was implemented designers would be free to determine whether there were any cost advantages in adopting the fully pressurised installation in any particular case and it would be for them to consider the various advantages and disadvantages of alternative installations.

In effect, this would apply to storage water heaters of a volumetric capacity over 3 gallons connected directly to the mains and under pressure from the mains because the present Model Water Byelaws permit instantaneous water heaters and storage water heaters capable of holding up to 3 gallons to be connected directly to service pipes under mains pressure.

1.02 Our aim has been to rationalise safety requirements and to recommend sensible precautions for water heating installations in dwellings where water heaters and boilers are not provided with vents open to atmosphere at all times.

1.03 For the avoidance of doubt and the convenience of the reader we include at Appendix A the meaning of terms adopted by the Committee.

1.04 Appendix B illustrates diagrammatically a number of examples of systems which incorporate our recommendations together with descriptions of the necessary safety measures.

* Fully pressurised was taken to mean (for purposes of the Backsiphonage Report) an installation where all the connected fittings and appliances are under pressure from a main.

CHAPTER 2

PRESENT PRACTICE IN HOT WATER SUPPLY INSTALLATIONS IN DWELLINGS

2.01 The traditional British domestic hot water supply installation is based on cold water feed from storage and is vented to atmosphere. It is essentially low pressure but in multi-storey dwellings static pressures at connected hot water taps can be high. However, certain types of water heating appliance may be served by cold water drawn from the supply pipes under mains pressure. These appliances are usually either instantaneous types of gas or electric water heaters or limited volume storage type water heaters; there are no statutory requirements for precautions to prevent bursting due to overheating or malfunction of controls.

2.02 Cases of bursting of hot water storage vessels and pipes as a result of malfunction of controls rarely arise in storage fed installations. This is because vent pipes are provided which prevent build up of steam under pressure in both primary and secondary circuits.

2.03 There is an extensive range of British Standards (for boilers, cylinders and fittings) and Codes of Practice (for materials, design, installation, testing, commissioning and maintenance) applicable to low pressure hot water supply and hot water heating installations.

CHAPTER 3

PRINCIPAL RECOMMENDATIONS FOR SAFETY IN UNVENTED WATER HEATING INSTALLATIONS

General

3.01 Our principal recommendations may be grouped conveniently under 5 headings as follows:

i. Fundamental objectives

ii. Control of energy input

iii. Limiting water temperature and pressure

iv. Safety devices

v. Installation and operation.

These are detailed in following paragraphs 3.02 to 3.19 and discussed in paragraphs 3.20 to 3.30.

Fundamental objectives

3.02 The design and installation of an unvented water heating system, having regard to heat or energy input, its control and heat dissipation, should be such that under no situation of operation, malfunction and failure of any part should steam be produced. This situation can only be ensured providing the highest water temperature at any time does not exceed 100°C. in systems which incorporate quality assured safety devices installed competently. The temperature of heated water at a point of use should be such as to pose minimal risk of scalding.

Control of energy input

3.03 The first line of defence to prevent temperatures of water exceeding 100°C in unvented water heating systems should be heat or energy input control. This control should be achieved by incorporating two independent types of safety device arranged to operate in sequence. The first type of device should thermostatically control the heat, energy or fuel input to a predetermined normal operating temperature. The second type of device should cut-out the heat energy or fuel input at a predetermined or designed high limit temperature.

3.04 The normal operating temperature should be a matter for the designer having regard to particular circumstances. The cut-out temperatures should not exceed the following:

i. water within a closed water heater, 90°C.

ii. water within a primary circuit, 100°C.

3.05 If the source of heat energy input is incapable of raising water temperatures to the limits recommended in paragraph 3.04, provision of either thermostatic activation or high temperature cut-out devices should not be a requirement.

3.06 In a system in which an unvented storage water heater is heated indirectly by means of a primary circuit, providing this circuit either is incapable of raising temperatures to 90°C or is protected by an appropriately set high limit cut-out device or a suitable thermal relief valve, provision at the water heater of either thermostatic control or high limit cut-out devices controlling heat input should not be a requirement.

3.07 A high temperature cut-out device activating the energy input or fuel valve should 'fail to safety' and having operated should only be re-set manually which may be with or without the use of special tools. The temperature selected for cut-out should be preset by the manufacturers and should not be capable of subsequent adjustment. Automatic cut-out devices should not be permitted.

Limiting water temperature and pressure

3.08 To prevent water within an unvented storage water heater from reaching a temperature above 100°C as a result of failure of devices controlling or cutting-out energy or heat input, a thermal relief valve should be installed on the water heater. The thermal relief valve should be in direct contact with water at the hottest part of hot water storage. It should be water temperature activated.

3.09 Thermal relief valves should be preset by the manufacturer and should not be capable of subsequent adjustment. Each valve should be sized having regard to the rate at which hot water needs to be discharged from the water heater so as to prevent water temperature exceeding 100°C. Regard should be paid to the water pressure head loss likely to occur when it is full open so that no restriction on discharge is imposed. Discharges of hot water should be arranged in such a way as to pose no risk of scalding.

3.10 In a system in which an unvented storage water heater is heated indirectly by means of a vented primary circuit which itself incorporates a suitably set thermal relief valve, provision of a second thermal relief valve on the associated water heater should not be a requirement.

3.11 To prevent bursting, water pressure within an unvented storage water heater or a boiler serving an unvented primary circuit should be restricted to a predetermined limit by means of an approved pressure relief valve.

3.12 In the case of an unvented storage water heater, the pressure relief valve should be installed on the cold water inlet and no other water fitting such as a stop valve or pressure reducing valve should be interposed between the water heater inlet and the pressure relief valve.

3.13 The pressure relief valve limiting water pressure in a boiler should be located either at the boiler flow or return connection.

3.14 A pressure relief valve should be of the diaphragm type where the springs are never in contact with the water. The difference between the pressure at which a valve commences to discharge water and the minimum pressure at which the valve is fully open should not exceed 0.6 bar. Valve discs should be of silicone rubber or equivalent.

Safety devices

3.15 All safety devices, fittings and equipment used in unvented water heating installations should fail to safety; that is, any fault or failure should result in an installation as a whole being safe.

3.16 All safety devices should be protected against irresponsible adjustment or interference. They should be either lockable or so arranged that they cannot be adjusted except by the use of special tools or only after removing protective shields. Safety devices should be installed on each new unvented water heater or boiler at the appliance manufacturers' works. The appliance should be delivered to site suitable for installation in as 'complete' a state as possible so as to avoid the necessity for the installer to obtain, affix or adjust any of the safety devices at the time the appliance is installed, tested and commissioned.

3.17 Safety devices should be manufactured in accordance with approved standards, subject to quality control during manufacture and be fit for their purpose.

Installation, testing and maintainance

3.18 Unvented water heaters and unvented primary circuits in dwellings should be designed, installed, tested and commissioned to approved Codes of Practice in a competent manner.

3.19 Subsequent to its commissioning, inspection of an unvented installation and, where feasible, testing of the safety devices should be carried out at prescribed intervals.

Considerations leading to the establishment of the principal recommendations

3.20 We are strongly of the opinion that in domestic hot water and heating installations potentially hazardous situations must be prevented as a result of the production of steam under pressure. We know that temperatures higher than 100°C are permitted abroad but despite this we consider that the most reliable safety requirement is one which prevents the instantaneous production of steam once a hot water storage vessel has burst open to atmosphere.

3.21 With this in mind, we consider that upper limits on temperatures should be prescribed. The proposed limits should not be unduly restrictive on designers. The limit selected by the designer in a particular case for the thermostat or energy cut-out should be decided by the need not only to prevent steam production under failure conditions but also for temperature increments to exist between normal operating temperature, high temperature energy cut-out and operation of a thermal relief valve. For example, settings of devices on an unvented storage water heater fitted with an electric immersion heater could be as follows: thermostat 60°C, energy cut-out 90°C and thermal relief valve 95°C.

3.22 We make no specific recommendations concerning temperature at the draw-off points of heated water. A water temperature of 46–50°C is as hot as most people can comfortably bear and immersion in water at 65°C can scald. As a generality, we think that the temperature of stored hot water should not exceed 65°C.

3.23 We consider that unvented water heaters and unvented primary circuits should be permitted only where the energy input can be controlled and limited. Immediate response of control or cut-out of the heat or energy input on attaining preset temperatures is essential; this requirement virtually eliminates the use of solid fuel as an energy medium providing heat in unvented primary circuits in domestic installations. However, vented primary circuits heated by solid fuel may be permitted to supply heat to unvented storage water heaters, providing primary water temperatures can be limited to 100°C.

3.24 We accept that occasions will occur of failure of thermostatic temperature control devices. Safety then depends upon the operation of other devices. It is essential that there is an opportunity for the cause of a fault to be identified and, if necessary, rectified before heating is allowed to re-commence. This can only be assured by the use of manual re-setting high temperature cut-out devices. Failure of any device, fitting or other component of a water heating installation should never result in an installation being otherwise than safe, that is, steam must not be produced and any hot water which is discharged must be led away at no risk of scalding.

3.25 In addition to automatic temperature limit of heat or energy input to an unvented water heater, we are strongly of the opinion that an additional temperature limit safety device should be installed as a third line of defence. Although failure of a high temperature cut-out device might be rare, we think that cases could occur. Independent assurance of being able to limit the temperature of stored hot water for use under pressure would be achieved by the use of a thermal relief valve. Such a valve would need to discharge heated water from an unvented water heater at a rate commensurate with the heat energy input. We envisage a requirement that an unvented storage water heater with integral coil or other means of transferring heat into the vessel from a hot water primary circuit would have a plate firmly fixed to the heater stating the heat transfer surface area. This would facilitate determination of the appropriate rating of the thermal relief valve in each case.

3.26 In an unvented and sealed heating system incorporating a domestic boiler, we consider that instead of requiring a thermal relief valve, it should be permissible to provide an additional high temperature cut-out device. Both devices should be set at the same temperature.

3.27 A pressure relief valve is required to prevent an unvented storage water heater from being subjected to excessive water pressure as might occur from failure to accommodate expansion water within the heater and its pipework or from the effects of water hammer. In a case where backflow of expansion water to the mains is deliberately prevented, the only methods of limiting the level of pressure build up when water is heated up from cold are either to accommodate the additional volume of water in a suitable expansion vessel or space, or to rely on a pressure relief valve to operate discharging water to waste until the excess pressure is relieved. Even though a suitable expansion vessel or space (known as a 'bubble top') may be used, it is conceivable that an occasion may arise when it is no longer effective, in which case reliance must be placed on the operation of the pressure relief valve. In cases where backflow of expansion water is not deliberately prevented, it is also conceivable that an occasion may arise when backflow is unwittingly prevented (for example, closure of an isolating stop valve on the cold water pipeline to effect a repair before shutting down energy input to the water heater). The pressure relief valve would then prevent pressure build up leading to bursting. The two devices (pressure and thermal relief valves) would effectively prevent bursting of unvented storage water heaters during heating up from cold providing they were of approved types and had been installed and maintained properly.

3.28 Providing gas fired instantaneous water heaters are fitted with water flow operated automatic gas valves, there is no need for temperature limit safety devices to be provided.

3.29 We consider that whenever possible all safety devices should be fitted to an appliance by the manufacturer before it leaves the works. Incorrect assembly on site by the installer must be avoided if a manufacturer is to be held in any way responsible for the safe operation of his appliance. Safety devices must be properly shielded so that they cannot be adjusted other than by a competent person.

3.30 Only quality assured safety devices including replacement units and spares which are fit for their purpose should be used. A high standard of competency in design and installation is necessary and each installation should be inspected and tested to the approval of the enforcement authority not only on initial commissioning but also at intervals thereafter. A study of the various factors involved will be necessary before the appropriate interval can be determined.

CHAPTER 4

UNVENTED WATER HEATERS PROVIDING HOT WATER FOR USE

General

4.01 We distinguish three categories of unvented water heaters which provide hot water for use, as follows:

i. Instantaneous heaters

ii. Water jacketed tube heaters

iii. Storage heaters.

4.02 Instantaneous heaters are appliances in which water is heated only whilst water flows through the appliance. Heat input commences subsequent to the opening of a terminal water fitting and ceases by the time that water flow has stopped as a result of closure of the fitting. Heat may be derived either from the combustion of gas or from electricity. Water is carried in conduits which usually have a large total surface area relative to the volume of water being heated. Conduits are of relatively small diameter and usually have high bursting strengths.

4.03 Water jacketed tube heaters (otherwise known as automatic heat exchange water heaters) are appliances in which water to be heated passes through water tubes or coils contained in a static reservoir of hot water on the opening of a terminal fitting. On closure of the terminal fitting, water remaining in the tubes continues to be heated until it attains the same temperature as the water in the hot water reservoir. Although the volume of water within the tubes or coils may be small, a degree of expansion of water occurs after flow ceases. If this slight backflow of expansion water is prevented pressures may be generated sufficient to result in failure and means may be necessary either to accommodate the expansion water or to relieve high pressures.

4.04 Storage water heaters are appliances in which water is heated within the appliance itself and is then held for subsequent use. Compared with instantaneous heaters these appliances have a much lower rate of heat input per unit volume of water heated. They usually have relatively low bursting strengths and must always be provided with pressure relief valves or vents open to atmosphere.

Draining down of water heaters

4.05 We consider that there are no safety reasons why the conduits in instantaneous or water jacketed tube heaters should be prevented from draining down as a consequence of a failure in the cold water supply. A burst main, supply or feed pipe serving one of these heaters could cause tubes to become emptied of water; however, the energy or fuel controls of instantaneous heaters should prevent heat being applied to the empty conduits and damage to the tubes would be avoided. In the case of water jacketed tube heaters, the hot water reservoir would always be at a temperature below 100°C and tubes would not be damaged.

4.06 In the case of an unvented storage type water heater, we consider that on safety grounds measures should be taken to ensure the heater is filled with water at all times, excepting when the installation or appliance is taken completely out of service.

The provision of an adequately sized upstand on the cold water feed pipe in association with means for admitting air would be satisfactory. If an approved check valve is located for some other reason at the heater inlet this fitting alone would prevent drain down. However, if the unvented storage heater is at the lowest level of a storage cistern fed installation, no special measures would be required.

Cold water feed to water heaters

4.07 If the requirements for safety recommended in paragraph 4.06 are met, there would be no need on safety grounds to require a separate cold water feed for each unvented water heater.

Back flow from a water heater

4.08 Unless it is prevented, backflow into the supply pipe could occur from an unvented water heater. Backflow might occur in two situations:

(a) sudden backflow on fall in pressure in the supply to an unvented water heater; and

(b) expansion water backflow on heating up of water within an unvented water heater.

4.09 Pressure failure in the water supply to an unvented water heater might occur from any one of a number of causes, such as a burst main or supply pipe or mains shut-down for waste metering operations. In these circumstances, reverse flows (backflow) may occur into the supply pipe from the water heater. The water heater would remain filled with water if the recommendations of paragraph 4.06 have been implemented. Heated water may backflow, the amount depending upon the displacement of hot water within the heater by cold or warm water backflowing from pipework located at levels above the top of the water heater on the heater delivery side.

4.10 We think that there would be no objection in principle to an infrequent occurrence of sudden backflow which results in warm water reaching the mains. The volume presently permitted to backflow under Model Water Byelaw 46 is 3 gallons (approximately 15 litres). There is no evidence concerning the frequency of occurrence, nor have we any evidence that problems have been caused through the operation of this part of the byelaw.

4.11 Concerning backflow as a result of water expansion, we suggest that no volumetric limit need be imposed. Instead, hot or warm expansion water should be required to be confined within that length of feed pipe serving the unvented water heater between the heater and the nearest junction of cold water service. This would prevent hot or warm water from being drawn into a cold water supply pipe and from thence to a cold water tap. For example, backflow on heating up a 135 litre unvented storage water heater from 5°C to 65°C could be about 2.5 litres. This volume could be 'contained' without difficulty or expense within an adequately sized upstand and supply pipe.

4.12 In the case of an unvented storage water heater served with cold water from a storage cistern, no measures are necessary to prevent backflow due to water expansion. If an isolating stop valve on the cold water feed were closed without first taking the heater out of service, the combination of pressure and temperature sensitive devices would prevent the heater from bursting.

Use of check valves

4.13 When check valves are used to prevent backflow, expansion water must be dealt with otherwise a burst is liable to occur. The pressure relief valve on the water heater inlet would relieve pressures by releasing water.

In the event that such discharges are not to be permitted, it will be necessary to require on an unvented water heater either to incorporate within its shell a suitable gas or air loaded expansion space (known as a bubble top) or to have a separate pressurised expansion vessel located between the check valve and the heater cold water inlet. In such cases, the design and installation of heater and expansion vessel merits careful attention.

4.14 We have studied the results of tests carried out at the Building Research Station, Watford, in which stop valves with loose jumpers have been assessed for their effect on preventing backflow. Our conclusion is that stop valves with loose jumpers can not be relied upon to either prevent or to permit backflow. Much depends upon the age of a valve, water quality, rate of backflow and manner of valve installation. We consider it could be an advantage if all stopvalves which contain loose jumpers were to be suitably marked in future.

4.15 We do not know of any bursts caused by preventing backflow of expansion water from instantaneous water heaters; it is therefore debatable whether stopvalves which have loose jumpers pose a risk to these heaters. However, unvented storage water heaters should incorporate pressure relief valves and in the event that a new unvented storage water heater is installed in an existing dwelling which is served by a supply pipe incorporating a stopvalve with loose jumper, the water heater will be safe. Should the pressure relief valve operate frequently as a result of a loose jumper preventing backflow, it will be necessary either to replace the stopvalve or to provide an expansion vessel.

Use of pressure reducing valves

4.16 We consider that the use of pressure reducing valves should be permitted. The advantages, be they economic or operational, from employing these fittings are matters for the designer and manufacturer. Because of possible waste of water, we assume that pressure reducing valves which are not effectively 'drop-tight' in the normal direction of flow would not be permitted.

4.17 We are aware of two categories of pressure reducing valve. The first is designed to permit backflow when pressures on the downstream side exceed pressures on the upstream side. The second prevents backflow under these circumstances. We point to the need for clear type stamping on these two types of valve to avoid their incorrect use.

Working pressures

4.18 Economic considerations dictate the working pressure classification of unvented water heaters and boilers. We recommend the following classification.

Table 1

Class	Suitable for a maximum pressure in service of	Works test pressure
1	3 bars	5 bars
2	6 bars	10 bars
3	10 bars	16 bars
4	16 bars	25 bars

4.19 Mains water pressures vary widely over the country and within undertakers' distribution systems. It is likely that over 80% of existing dwellings receive supplies drawn from mains which are suitable for normal working pressures up to 6 bars. We consider that it is the responsibility of the designer and installer to be satisfied a particular installation matches the present or likely future mains pressures available. It is present practice for the installer to have regard to available pressures to deliver water to the various points of use. We envisage no change as a result of permitting mains fed unvented storage water heaters of capacity over 3 gallons.

4.20 The designer and installer must recognise that the undertaker is free to increase pressure at a future date and may do so from time to time. The undertaker should notify consumers when he proposes to introduce significant increases in pressures which would necessitate the consumer seeking advice concerning the adequacy of his water heater, pressure relief valve or pressure reducing valve to sustain the higher pressure. The undertaker need only be obliged to re-set pressure relief valves or at least to arrange for such a service, possibly on a repayment basis. If replacement units were required, we recommend that these should be installed to the approval of the enforcement authority.

4.21 A Class 1 unvented storage water heater should be permitted to be supplied under pressure only from a cold water storage cistern. This has applications in certain situations such as high rise flats.

4.22 To avoid limiting the future operations of the water undertaker it may prove necessary for the working pressures of unvented systems connected direct to the water mains to be required to be not less than Class 2. This class would comprise the majority of cases. In cases where mains pressure is at present under 6 bars but may exceed this pressure at some future date, the undertaker should inform the consumer of this possibility. The consumer would then have the choice of designing for the higher pressure or of providing for the future installation of a suitable pressure reducing valve.

4.23 Pressure drop as a consequence of a burst main, exceptional draw-off (to fight a fire) or high demand for water at peak use periods could result in pressure falling below the highest draw-off level associated with the heater. However, if our recommendations have been observed, the installation will be safe. The water

CHAPTER 5

UNVENTED SEALED PRIMARY CIRCUITS

5.01 We distinguish three categories of unvented sealed primary circuits:

i. a self-contained system incorporating a boiler serving one or more unvented or vented storage water heaters in a dwelling;

ii. a circuit such as a district heating system or one from a centralised boiler operating at temperatures above 100°C serving a number of storage water heaters which are located in dwellings such as flats; and

iii. as (ii) but the circuit serves storage water heaters which themselves each serve a number of dwellings.

5.02 As regards (i) above, measures for safety are those outlined previously. We suggest that these primary circuits should be permitted if design maximum pressures do not exceed 6 bars (ie Class 2 in Table 1).

5.03 Concerning (ii), we think that these systems should be the subject of separate study. Requirements for safety might be more stringent than those proposed for (i) above because they would have to deal with the installation and maintenance of energy input controls and thermal relief valves required to safeguard unvented water heaters. Where systems are based on boiler installations located within a building block such as a block of flats, operation and supervision of automatic self-contained systems and the routine maintenance would best be undertaken under contract by suitably competent persons.

5.04 As regards (iii), in addition to the remarks above, consideration should be given to duplicating the thermal relief valve on each unvented storage heater, one could be set at a temperature close to the designed normal operating temperature.

CHAPTER 6

UNVENTED PRIMARY CIRCUITS UNDER MAINS PRESSURE

6.01 We envisage that unvented primary circuits incorporating domestic boilers might be proposed for use under mains pressures. It would be for the designer to decide whether there is any advantage to be obtained compared with the unvented sealed system.

6.02 If unvented primary circuits under mains pressure were permitted, safety measures would be necessary, including:

i. temperature control and cut-out devices,

ii. thermal relief valves,

iii. pressure relief valves, and

iv. means for prevention of draining down.

6.03 We suggest that these circuits, if permitted, should be restricted to design maximum pressures not exceeding 6 bars (ie Class 2 in Table 1). Similar considerations to the above also apply to unvented primary circuits connected direct to a feed and expansion cistern.

CHAPTER 7

ENFORCEMENT OF REQUIREMENTS FOR SAFETY

7.01 Enforcement requirements must be clear. We think that the enforcement authority should have the duty of satisfying itself that unvented storage water heaters and unvented domestic boilers should be of approved types which have been properly commissioned and tested. We do not consider that enforcement authorities should necessarily have to undertake tests themselves.

7.02 As regards continuing requirements, we suggest that the enforcement authority should be permitted to accept the certificate of a competent person that the installation is safe and that such certificates should be called for at prescribed intervals. In the absence of statutory definition, we suggest that enforcement authorities should be given the power to determine which persons they consider to be 'competent'.

7.03 If suitable standards for components and a code of practice for unvented hot water systems were available, which they are not, certificates could refer directly to them. Adequate safety factors must be incorporated against scale, corrosion and metal fatigue (see Chapter 8).

CHAPTER 8

MISCELLANEOUS ASPECTS

8.01 Scaling, metal fatigue and corrosion may inhibit the effective operation of pressure and temperature sensitive devices. The character of the water is an important factor. We recommend that water regulations should include provisions limiting the normal working temperature of unvented storage water heaters in areas where there is an established history of problems arising from scale formation.

8.02 Metal fatigue and corrosion can lead to failure of safety devices and pressure vessels. Standards covering these factors would be an important part of the safe introduction of unvented water heating systems. They would enable enforcement authorities to evaluate certificates issued by competent persons.

CHAPTER 9

SUMMARY OF PRINCIPAL MEASURES FOR SAFETY

9.01 Our recommendations may be summarised as follows:

1. The design and installation of unvented hot water and heating systems serving dwellings should be such that the highest water temperature at any time should not exceed 100°C.
2. The first two lines of defence should be automatic controls and limit devices on the energy or heat input so designed as to ensure that temperatures are controlled not to exceed 100°C.
3. The third line of defence against temperature exceeding 100°C in storage types of unvented heaters should be thermal relief valves.
4. To prevent bursting of unvented storage water heaters and unvented primary circuits due to failure to accommodate expansion water, means should be provided for this water to be accommodated within the system either by permitting backflow (in the case of water heaters) or by provision of sealed expansion vessels (in both cases).
5. As a last line of defence against bursting due to failure to accommodate expansion water within the system, pressure relief valves should be provided on the cold water inlet to unvented storage water heaters and within sealed primary circuits.
6. In all cases where thermal relief valves have been provided, measures should be taken to prevent unvented storage water heaters from draining-down due to failure in the cold water supply.
7. Safety devices should be quality assured products and installations should be inspected and tested to the approval of the enforcement authority.

APPENDIX A

MEANING OF TERMS

Hot water for use
Means heated water suitable for domestic use.

Mains supply (to a water heater)
Means a cold water supply drawn from the public mains direct to a water heater. The pressure at a water heater inlet will depend upon mains pressure (or a pressure reducing valve, if fitted in the supply pipe) and pressure losses in the supply pipe from the mains or reducing valve to the heater inlet. The rate of flow of cold water into the heater will depend upon the available pressure at the heater inlet and the nature and disposition of heated water delivery pipework and connected water fittings and appliances drawing off heated water.

Cistern supply (to a water heater)
Means a cold water supply drawn from a cold water storage cistern direct to a water heater. Pressure and rate of flow of water at the water heater inlet will depend upon the nature and disposition of cold water and heated water delivery pipework and connected water fittings and appliances drawing off heated water.

Water heater (providing hot water for use)
An appliance in which water is heated providing hot water for use being a vessel or an arrangement of pipes.

Storage vessel (for hot water)
A vessel such as a cylinder or tank capable of holding hot water under pressure greater than atmospheric pressure.

Unvented water heater
An unvented water heater is one which connects hydraulically to atmosphere only at a point of discharge of hot water when a draw-off tap or other fitting is opened, at which time the pressure within the water heater may or may not drop significantly. Unvented water heaters are categorised as follows: instantaneous, water-jacketed and storage types. Within these appliances under conditions of both draw-off and no draw-off, hot water could be contained in cylinders or pipes under pressure (above atmospheric) in one of a number of ways such as (a) under mains supply with or without pressure reduction; (b) from cistern supply (under gravity or pump pressure) or (c) under self-generated pressure (as a result of the accommodation under pressure of expansion water produced by the water heater). These appliances are not provided with a vent permanently open to the atmosphere.

Instantaneous water heater (gas or electric)
An appliance in which water is immediately heated as it passes through the appliance to the point of usage. The flow of hot water can continue as long as required. For any particular hot water temperature, the rate of delivery will depend upon the gas rate or electric power rating and the initial water temperature. Some designs include water pressure reducing valves and thermostats.

Water jacketed tube heaters
An appliance in which water passes to the point of use in tubes or coils containing water to be heated and which are immersed in a reservoir of hot water. The reservoir usually is a vessel with a surface vented to atmosphere in which water is heated under thermostatic control.

Storage water heater
A water heater in which the water after being heated is held in readiness for subsequent use.

Boiler (independent domestic)
An appliance providing hot water for a primary circuit in which water is heated.

Circulator (gas fired)
An appliance in which water is heated and which is connected to a hot water storage vessel by flow and return pipes in which natural circulation can take place. When these pipes form a primary circuit, the circulator is a form of boiler but if the pipes draw stored water from and return it to the storage vessel itself, then the circulator is a form of water heater.

Primary circuit
The flow and return circuit through which water circulates between a domestic boiler and a storage water heater. The associated storage heater, often called an indirect cylinder, in this case contains a subsidiary heat exchange vessel or coil usually referred to as a calorifier, through which primary circuit water flows permitting heat to be transferred to the surrounding water. The primary circuit might also circulate water between the boiler and water filled radiators in a space heating system.

Vented primary circuit
A primary circuit which is provided with a vent pipe permanently open to the atmosphere. At present, these are usually cistern fed circuits with vent pipes which terminate at levels above the top levels of the cisterns; the cisterns are usually referred to as feed and expansion cisterns.

Unvented primary circuit
A primary circuit which is not provided with a vent pipe which is permanently open to the atmosphere.

Sealed primary circuits
The circuit is not directly connected with a mains water supply. To accommodate expansion water, sealed expansion vessels are used.

Secondary system
The secondary system includes the cold water feed pipe, water heater and flow and return pipework from which hot water for use is conveyed to all points of draw-off. The lengths of pipe from a water heater, hot water storage cylinder or hot water flow and return pipe to the points of draw-off are limited under the Model Water Byelaws.

Vented secondary system
A secondary system which is provided with a vent pipe permanently open to the atmosphere. At present, these are usually cistern fed systems with vent pipes which terminate at levels above the top levels of the cisterns.

Unvented secondary system
A secondary system which is not provided with a vent pipe permanently open to the atmosphere.

Safety device
Means an approved measure or device or combination specifically designed to provide safety in use of a water installation.

Backflow or backsiphonage from a draw-off point through a closed water heater may be prevented by means of air gaps and combinations of anti-vacuum valves or vent pipes in association with upstands and in certain cases check valves (depending on whether supply is mains or cistern fed).

Various types of safety devices are associated with unvented water heaters to prevent overheating or bursting. These include: high temperature cut-outs, water pressure relief valves and thermal relief valves.

Operation of a device
Means operation of a device such as a high temperature cut-out, thermal relief valve or pressure relief valve so that the appliance, circuit, system or installation is safe.

Cut-out device (high temperature)
Means a device intended to shut off the energy input to a water heater or boiler in the event that a thermostat has failed to operate. In practice, it operates a fuel or energy valve other than that used for normal temperature control.

Operating temperature

i. of a thermostat, means the temperature at which it shuts off the heat or energy input;

ii. of a thermal relief valve, means the temperature at which the valve opens to atmosphere permitting discharge of hot water; and

iii. of a water heater, means the designed normal working temperature of the hottest water in a water heater.

Sealed expansion vessel
Otherwise known as a flexible membrane vessel is usually of welded steel construction into which is fitted a flexible diaphragm dividing it into two compartments, one of which is filled with nitrogen or air and the other with water from the heating system.

The vessel must be large enough to take on the expansion volume when the water in the circuit rises and expands. The volume is dependent upon the water capacity and the working temperature range in the installation.

Water flow operated automatic gas valve
Means a gas control on an instantaneous gas fired water heater operated by the pressure difference created by water flow through a venturi throat.

Approval (of a device or measure)
Means a safety device or measure approved by the enforcement authority.

APPENDIX B

EXAMPLES OF THE APPLICATION OF SAFETY MEASURES TO UNVENTED WATER HEATING INSTALLATIONS

1. The following examples are intended only as illustrations of the application of various safety measures which are recommended in this Report in respect of unvented water heating installations incorporating water heaters and boilers.

2. It should not be assumed that any particular example is recommended as 'good practice' by the Committee. On the contrary, there might be good reasons outside the scope of this Report why particular examples shown should not be permitted or permitted only under particular conditions.

3. It will be evident that many more examples could have been produced in which installations incorporate several different types of water heaters. Further, water heaters could have been shown deriving heat input from two or more sources.

4. The examples show a number of 'multiple' units within a single installation, as might occur in a block of flats. In these cases, the diagram show in outline the requirements for the application of 'whole installation' protection recommended in Chapter 8 of the Report of the Committee on Backsiphonage in Water Installations. It is necessary to mention this because the recommended methods of applying 'whole installation' protection could involve various alternative combinations of anti-vacuum valves, check valves, upstands and cistern air inlet pipes. The use of upstands could not only prevent drain-down but could influence volumes of water in backflow. Further, the use of a check valve at the junction of a supply pipe with the communication pipe could lead to the need for sealed expansion vessels at unvented storage water heaters. This will be a matter for the designer of the cold and hot water services to a building in multi-occupancy.

5. The following categories of examples are illustrated:

Instantaneous gas water heaters
Cases 1A to 1D

Unvented water heaters
Cases 2A to 2P

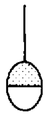
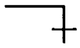
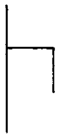
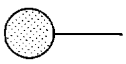
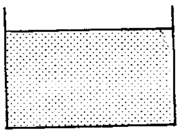
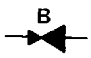
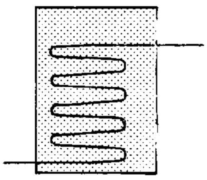
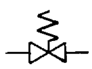
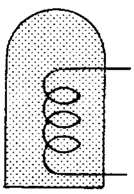
Vented primary circuits providing heat to water jacketed tube heaters and unvented storage heaters
Cases 3A to 3J

Unvented sealed primary circuits
Cases 4A to 4D

Unvented primary circuits, mains supplied
Cases 5A to 5D

Dual heating systems for water heaters
Case 6

Symbols used in examples of systems

WH	unvented water heater		automatic air vent and air purger
B	boiler		expansion vessel
C	gas circulator		hot water draw-off
T	thermostat		upstand
CO	high temperature cut out		cistern air inlet pipe
SV	storage vessel		terminal anti-vacuum valve
	mains cold water supply		stop-valve
	cistern fed cold water supply		check-valve (flow L to R)
	instantaneous water heater		pressure reducing valve (flow L to R) which permits back-flow
	water jacketed tube heater		pressure reducing valve (flow L to R) not permitting back-flow
	element of electric immersion heater		spring loaded diaphragm pressure relief valve
	heat transfer coil in an unvented storage water heater		temperature sensitive (thermal relief) valve
	normal direction of flow		automatic gas valve

Case 1A

Single unit cistern fed heater.

Case 1B

Multiple units cistern fed heaters.

Case 1C

Single unit mains fed heater.

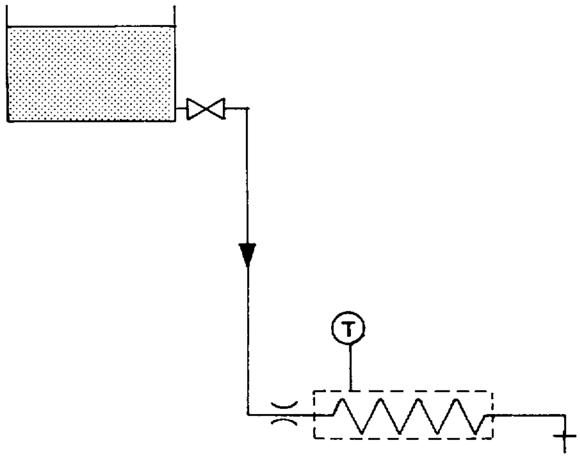
Case 1D

Multiple units mains fed heaters.

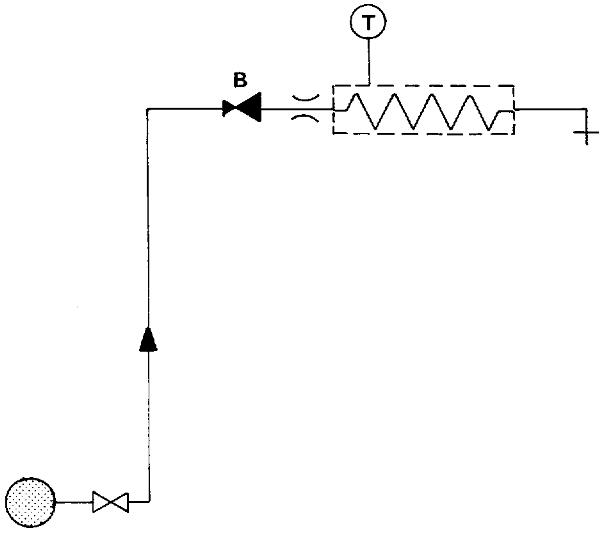
Heaters may be optionally fitted with:

i. thermostats
ii. pressure reducing valves (types which permit backflow).

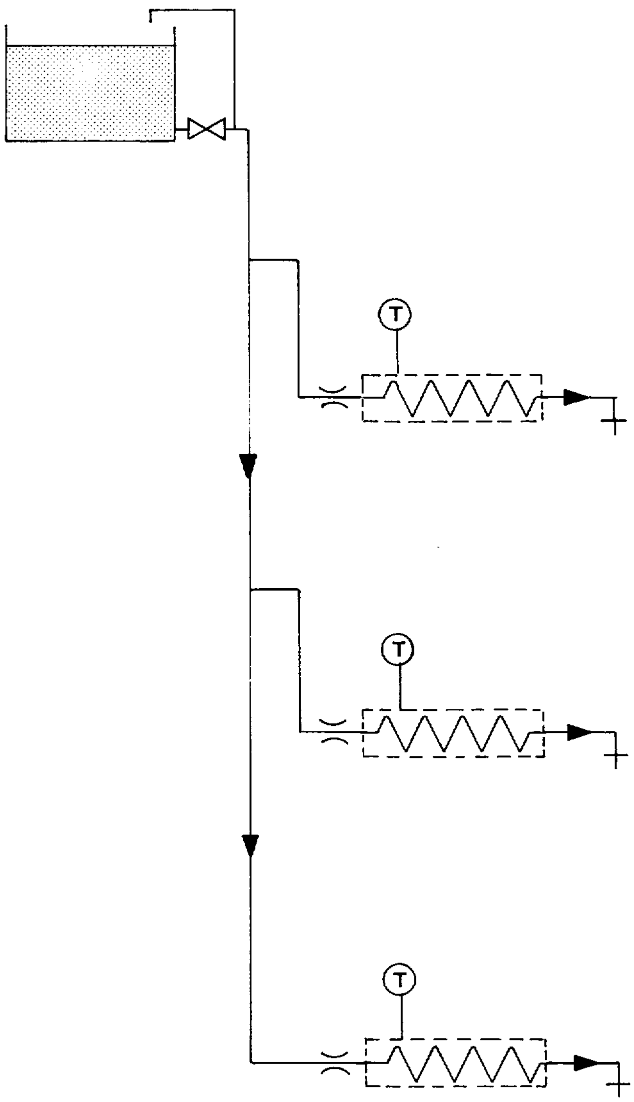
Case 1A



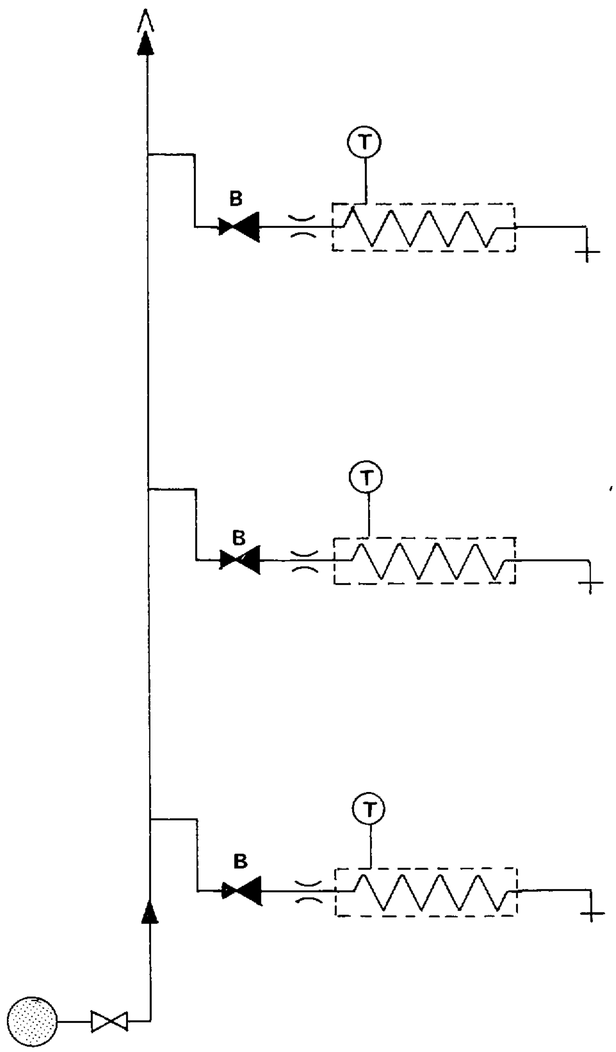
Case 1C



Case 1B



Case 1D



Case 2A

Single unit cistern fed heater fitted with an electric immersion heater.

Heater provided with:

i. thermostat
ii. high temperature energy cut-out
iii. thermal relief valve
iv. pressure relief valve

Case 2B

Multiple units cistern fed heaters fitted with electric immersion heaters.

Case 2C

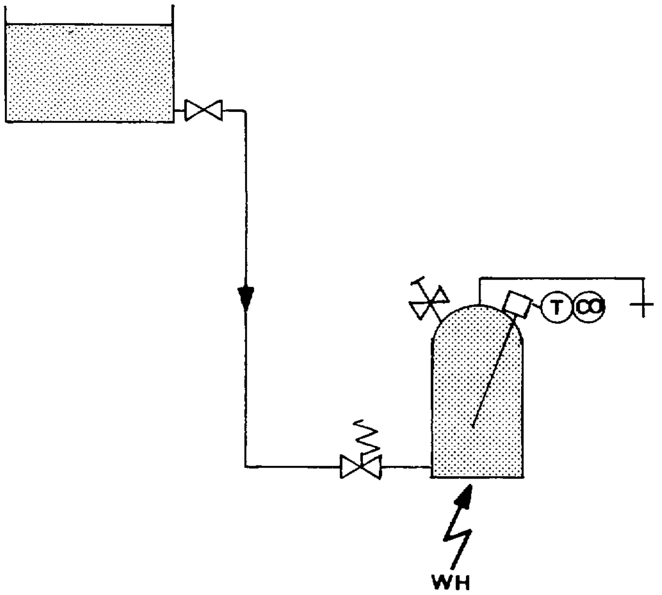
Single unit mains fed heater fitted with an electric immersion heater.

Case 2D

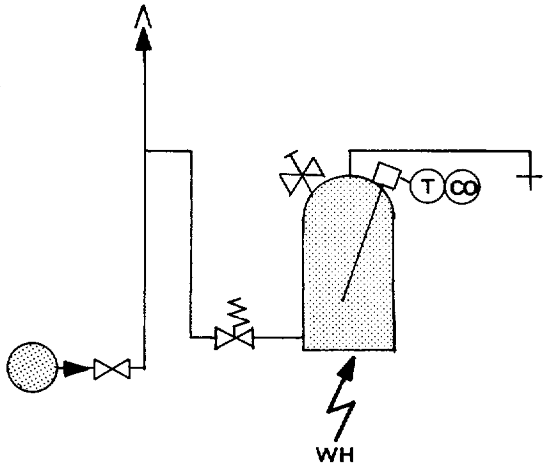
Multiple units mains fed heaters fitted with electric immersion heaters.

Each water heater, as Case 2A above.

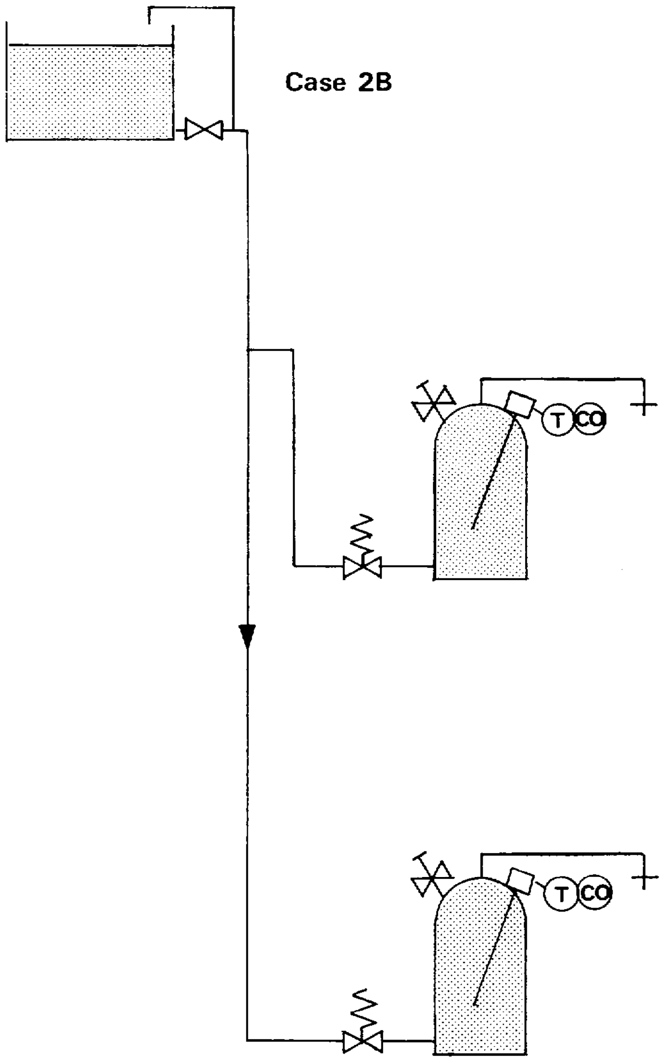
Case 2A



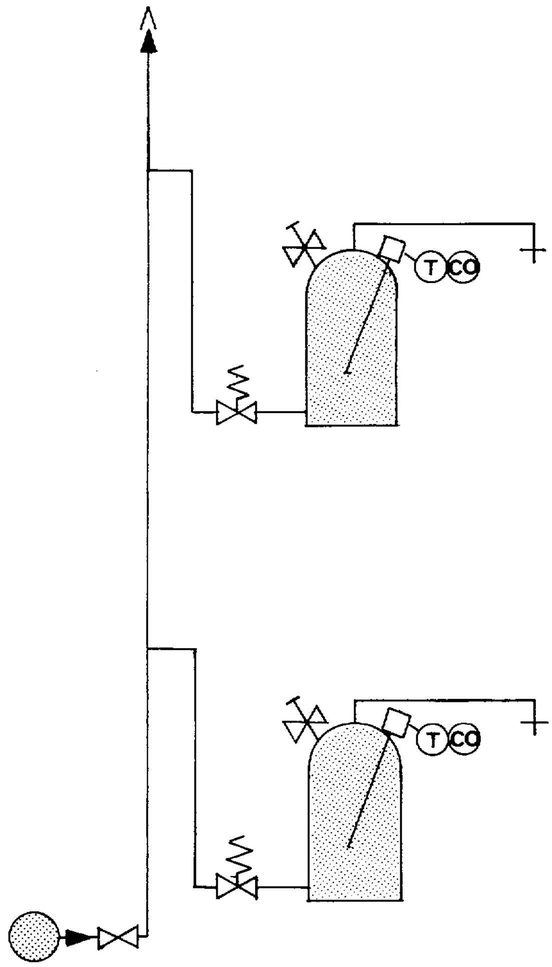
Case 2C



Case 2B



Case 2D



Case 2E

Single unit mains fed heater fitted with an electric immersion heater and a check valve in the cold feed pipe.

Heater fitted as Case 2A. If heater is not a 'bubble top' type, an air or gas loaded expansion vessel is located between the check valve and the pressure relief valve in the cold water feed pipe.

Case 2F

Single unit mains fed heater fitted with an electric immersion heater and a pressure reducing valve (non-backflow type) in the cold feed pipe.

Heater, as Case 2E above (with pressure reducing valve in place of the check valve).

Case 2G

Single unit mains fed heater fitted with an electric immersion heater and a pressure reducing valve (backflow permitted type) in the cold feed pipe.

Heater, as Case 2A but with pressure reducing valve.

Case 2H

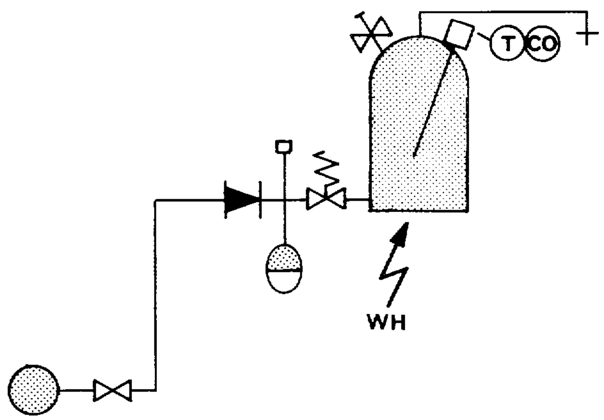
Multiple units mains fed heaters fitted with electric immersion heaters.

Heater no. 1 – as Case 2F.

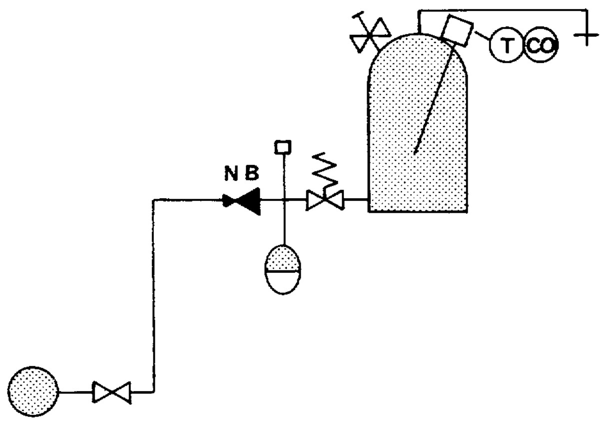
Heater no. 2 – as Case 2E.

Heater no. 3 – as Case 2G.

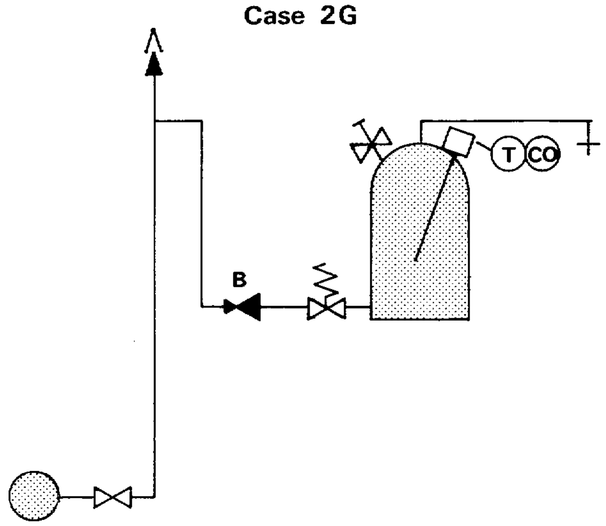
Case 2E



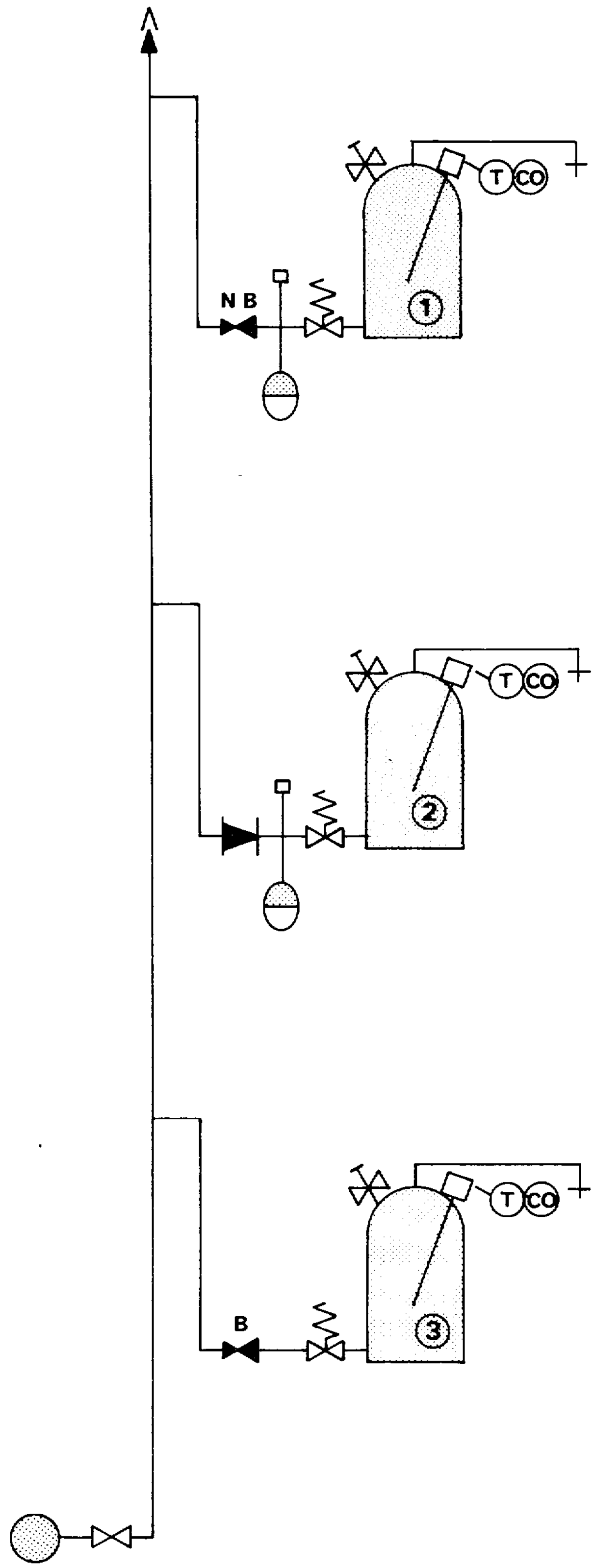
Case 2F



Case 2G



Case 2H



Case 2J

Single unit cistern fed heater with integral gas circulator as Case 2A.

Case 2K

Single unit cistern fed hot water storage vessel with separate gas circulator heater.

Gas circulator heater, as Case 2A.

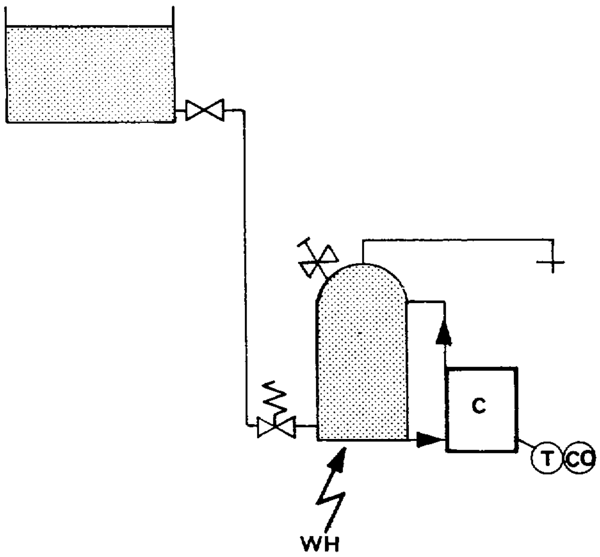
Case 2L

Multiple units cistern fed heaters (heating by gas circulators).

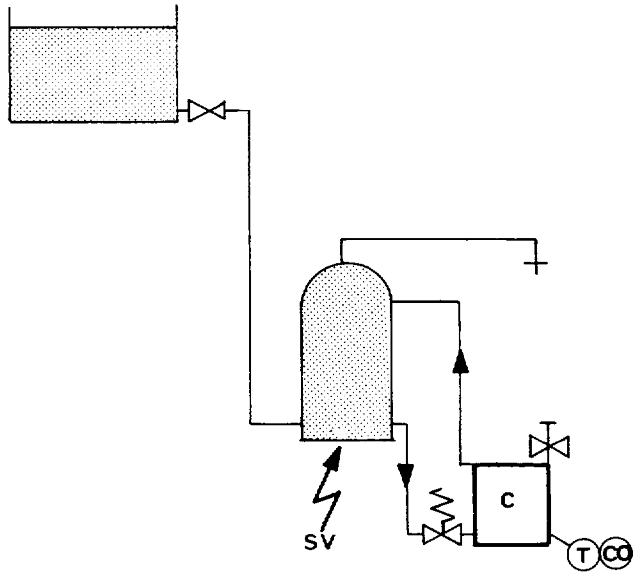
Heater no. 1 – as Case 2J.

Heater no. 2 – as Case 2K also fitted with a pressure reducing valve (backflow permitted type).

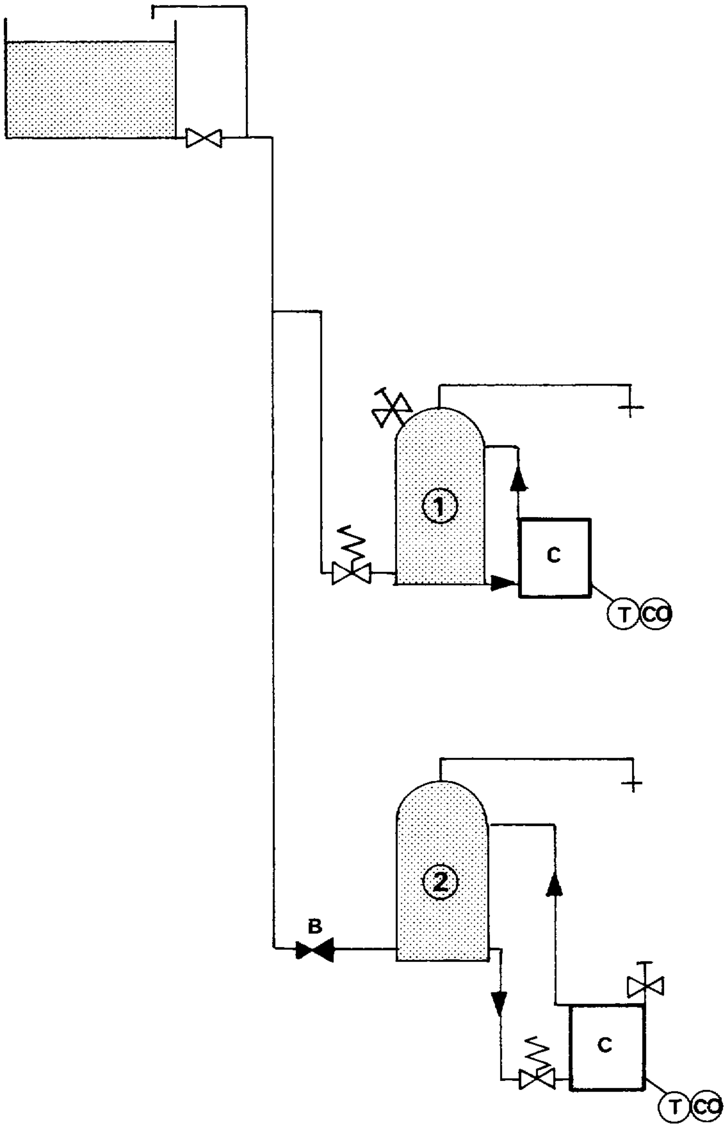
Case 2J



Case 2K



Case 2L



Case 2M

Single unit mains fed heater with integral gas circulator.

As Case 2A.

Case 2N

Single unit mains fed hot water storage vessel with separate gas circulator heater.

Gas circulator heater, as Case 2A.

Case 2P

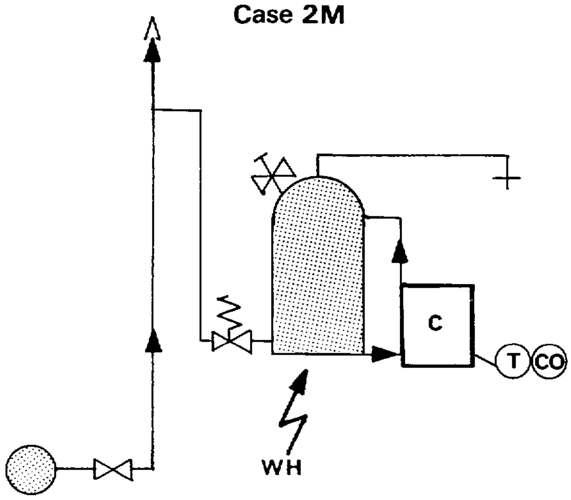
Multiple units mains fed heaters (heating by gas circulators).

Heater no. 1 – as Case 2M also fitted with a check valve on the heater cold water inlet.

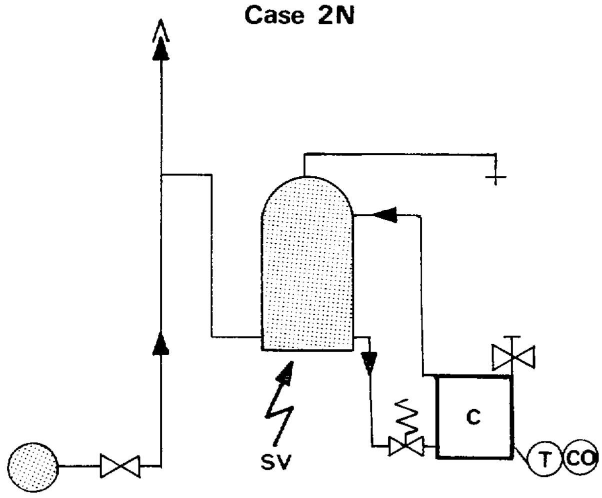
If heater is not a 'bubble top' type, an air or gas loaded expansion vessel is located between the check valve and the pressure relief valve in the cold water feed pipe.

Heater no. 2 – As Case 2N but with a pressure reducing valve (non-backflow type) on the hot water storage vessel cold water feed pipe. An air or gas loaded expansion vessel is located in the cold water feed pipe to the storage vessel.

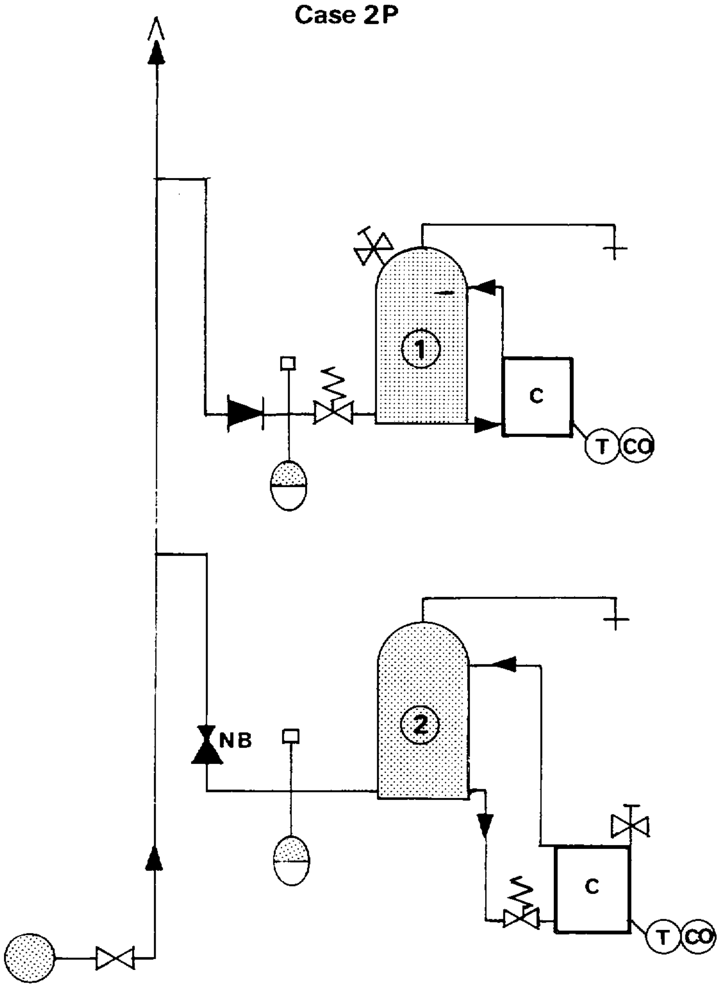
Case 2M



Case 2N



Case 2P



VENTED PRIMARY CIRCUITS PROVIDING HEAT TO WATER JACKETED TUBE HEATERS AND UNVENTED STORAGE HEATERS

Case 3A

Single unit cistern fed water jacketed tube heater.

Secondary system – no measures.

Primary circuit – cistern fed vented hot water reservoir; heating by electric immersion heater provided with a thermostat and high temperature energy cut-out.

Case 3B

Multiple units cistern fed water jacketed tube heaters.

Individual primary circuits – as Case 3A.

Case 3C

Single unit mains fed water jacketed tube heater.

Secondary system – pressure reducing valve (backflow permitted type).

Primary circuit – as primary circuit in Case 3A.

Case 3D

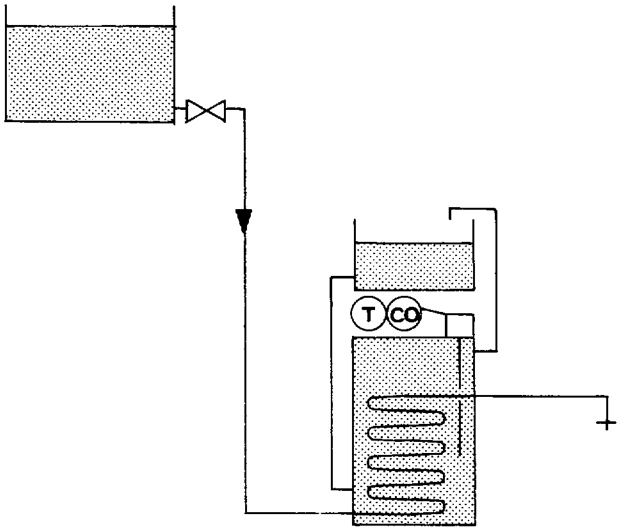
Multiple units mains fed water jacketed tube heaters.

Secondary systems – pressure reducing valves (backflow permitted type).

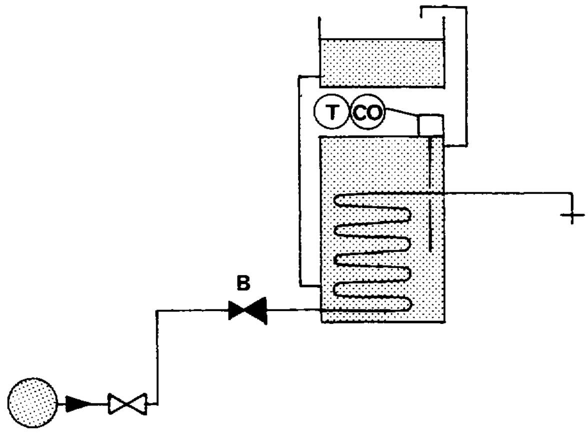
Individual primary circuits – as primary circuit in Case 3A.

Note: Similar considerations would apply if the electric immersion heaters were replaced by gas circulators which were integral with the respective hot water storage reservoirs.

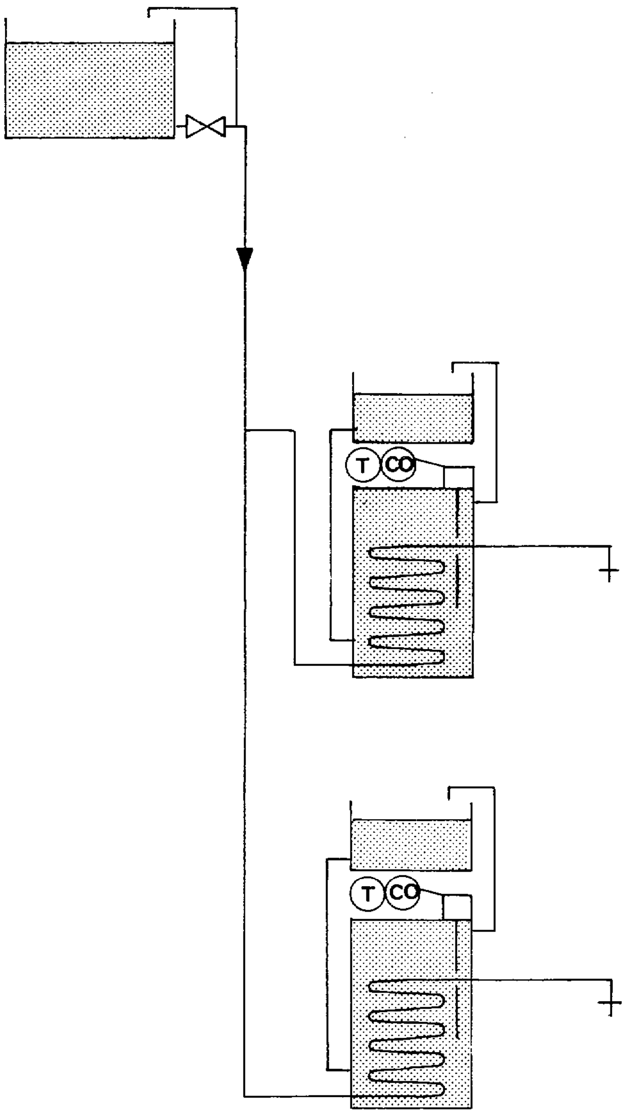
Case 3A



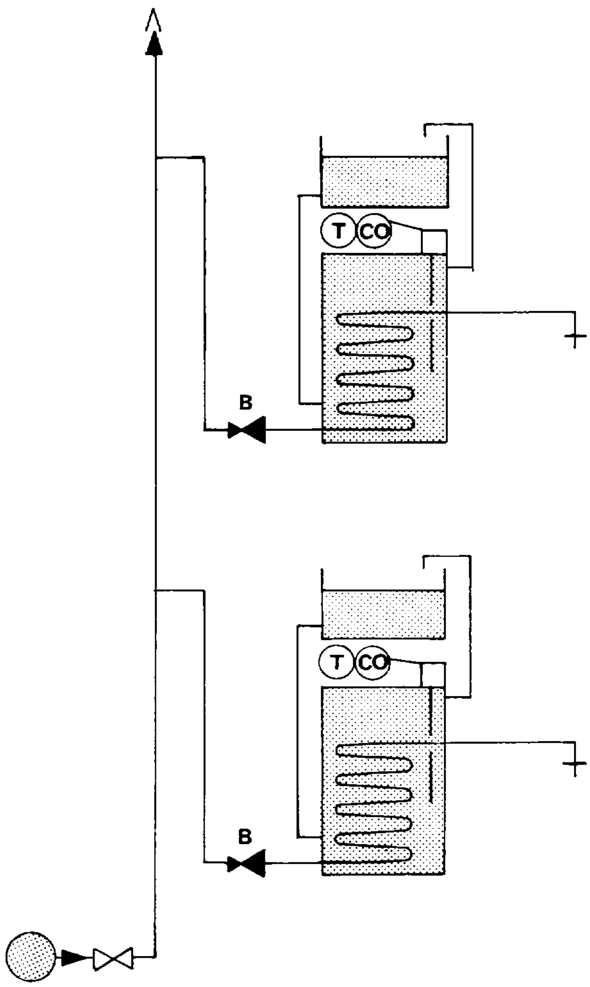
Case 3C



Case 3B



Case 3D



Case 3E

Solid fuel vented domestic boiler in primary circuit serving a single unit unvented storage water heater.

Primary circuit: boiler provided with:

i. thermostatically controlled damper,

ii. thermal relief valve (set below 90°C),

iii. pressure relief valve, and

iv. vent on 'flow' pipe serving water heater.

Secondary system: water heater provided with:

i. pressure relief valve.

Case 3F

As Case 3E.

Primary circuit: boiler provided with:

i. thermostatically controlled damper,

ii. pressure relief valve, and

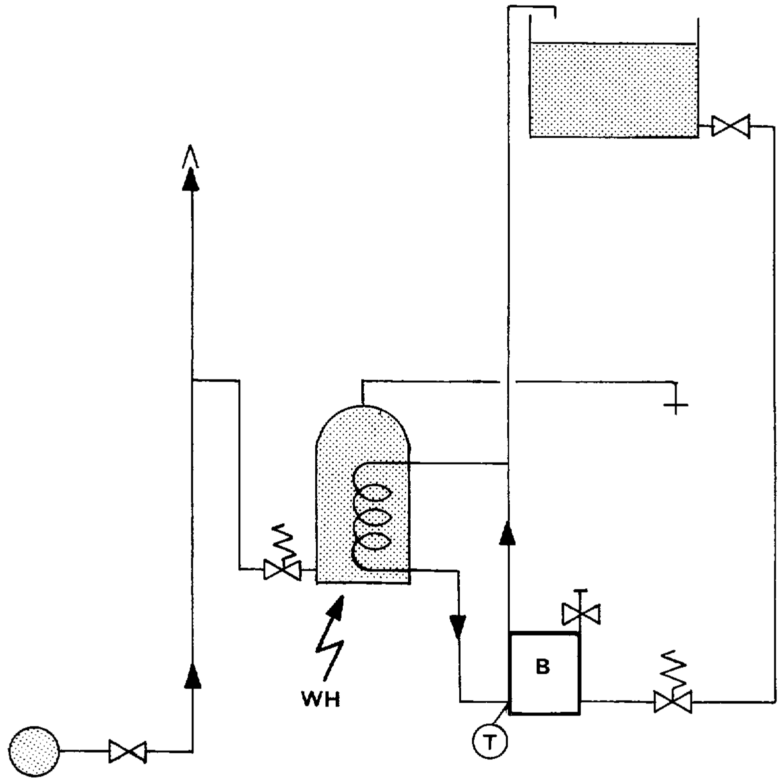
iii. vent on 'flow' pipe serving water heater.

Secondary system: water heater provided with:

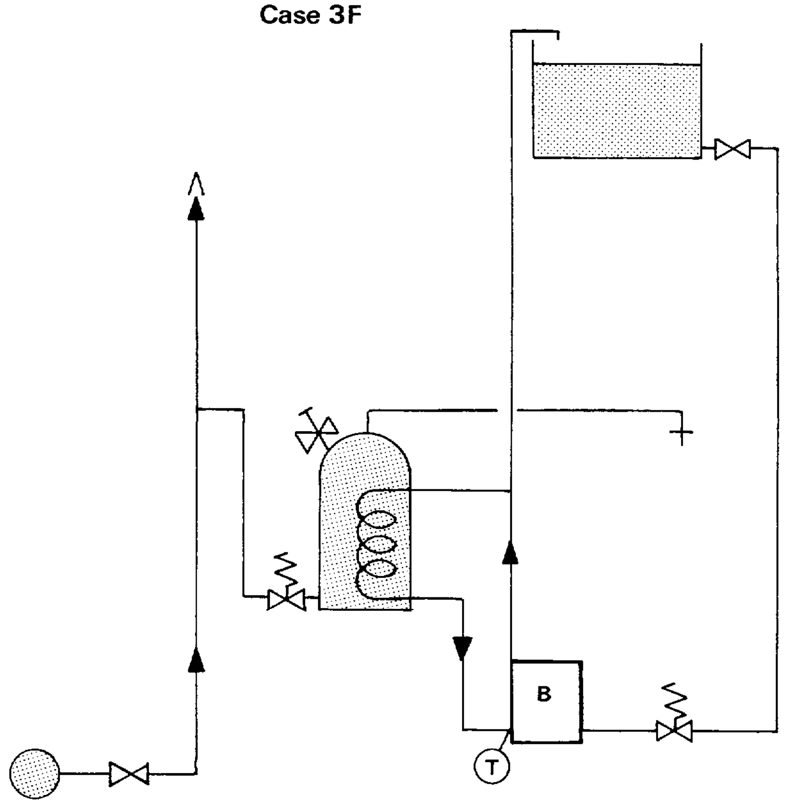
i. pressure relief valve, and

ii. thermal relief valve (set below 90°C).

Case 3E



Case 3F



Case 3G

Oil or gas fired vented domestic boiler in primary circuit serving a single unit unvented storage water heater.

Primary circuit: boiler provided with:

i. thermostat,
ii. energy cut-out or thermal relief valve (set below 90°C),
iii. pressure relief valve, and
iv. vent on 'flow' pipe serving water heater.

Secondary system: water heater provided with:

i. pressure relief valve.

Case 3H

As Case 3G

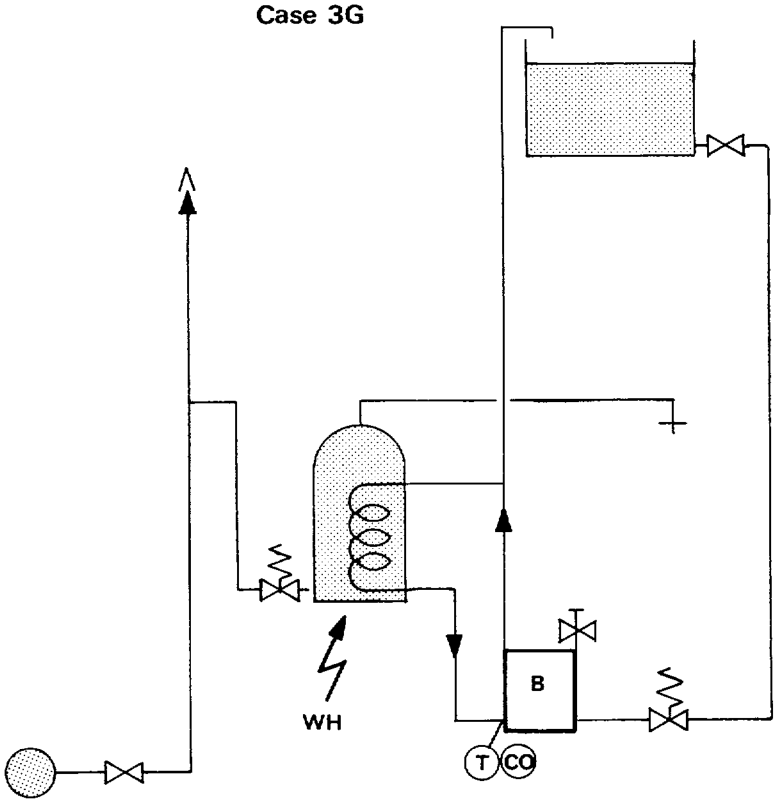
Primary circuit: boiler provided with:

i. thermostat,
ii. energy or fuel cut-out (set up to 100°C),
iii. pressure relief valve, and
iv. vent on 'flow' pipe serving water heater.

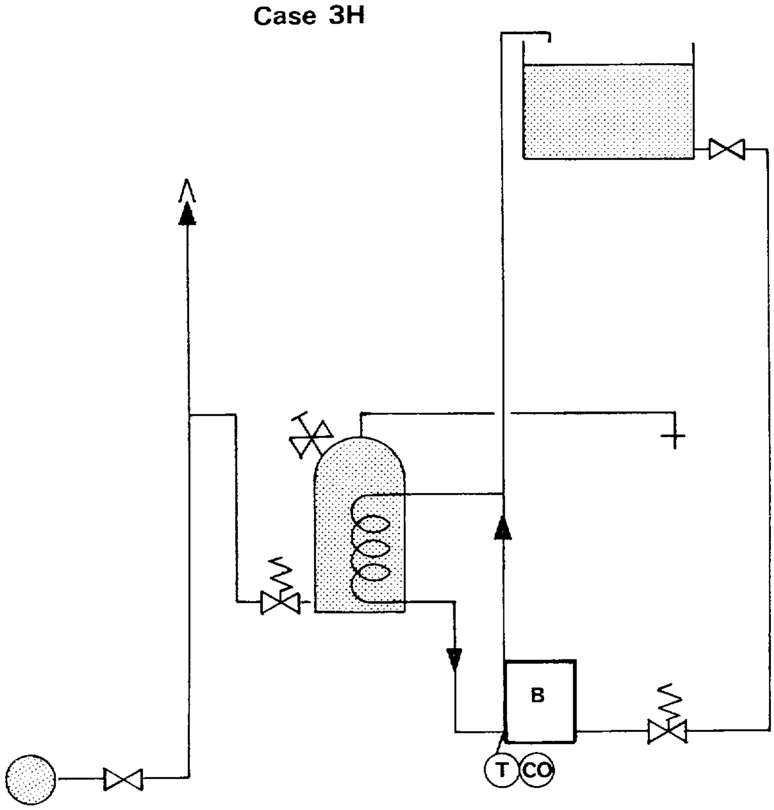
Secondary system: water heater provided with:

i. pressure relief valve, and
ii. thermal relief valve (set below 90°C).

Case 3G



Case 3H



Case 3J

Multiple vented primary circuits serving unvented storage heaters (mains fed).

Primary circuits

Boiler no.1 – as Case 3E

Boiler no.2 – as Case 3F

Boiler no.3 – as Case 3G

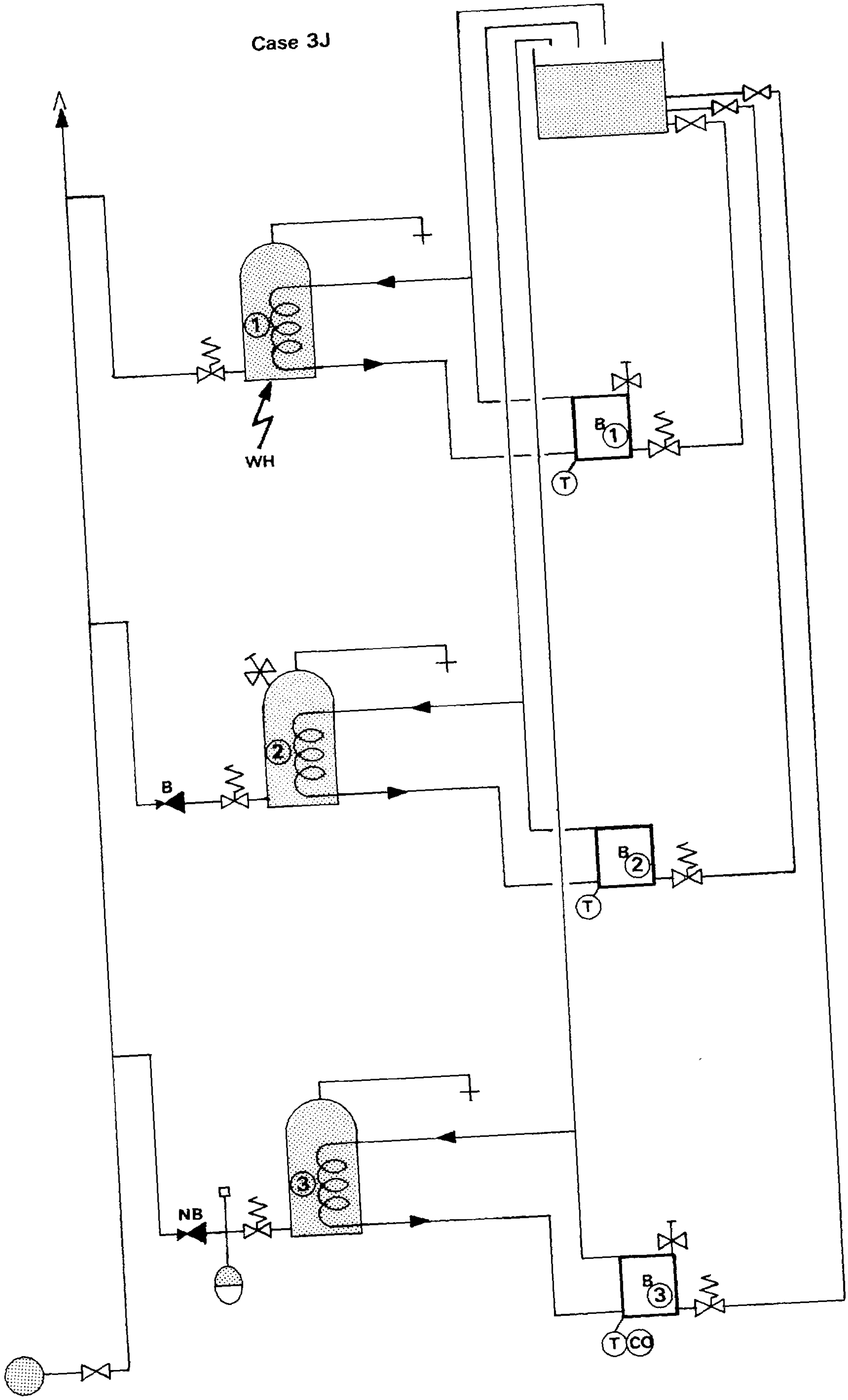
Secondary systems

Heater no.1 – as Case 3E

Heater no.2 – as Case 3F with a pressure reducing valve (backflow permitted type) upstream of pressure relief valve, in cold water inlet.

Heater no.3 – as Case 3G with a pressure reducing valve (non-backflow type) and an air or gas loaded expansion vessel upstream of pressure relief valve in cold water inlet.

Case 3J



Case 4A

Gas or oil fired domestic boiler in a sealed primary circuit providing heat to a vented water heater.

Primary circuit provided with:

i. thermostat,
ii. duplicate energy or fuel cut-outs (set at or below 100°C),
iii. pressure relief valve, and
iv. air or gas loaded expansion vessel.

Case 4B

As Case 4A

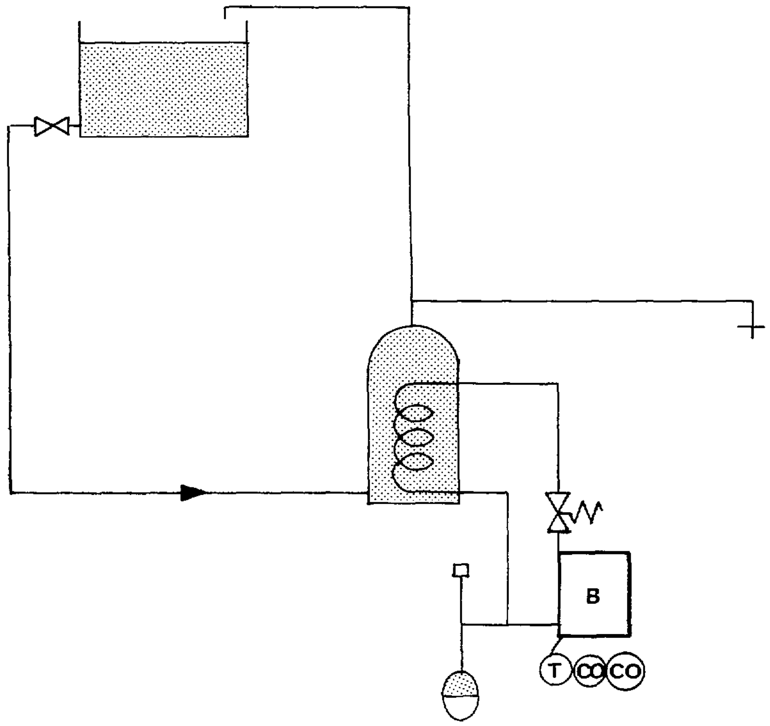
Primary circuit provided with:

i. thermostat,
ii. energy or fuel cut-out (set below 100°C),
iii. pressure relief valve, and
iv. air or gas loaded expansion vessel.

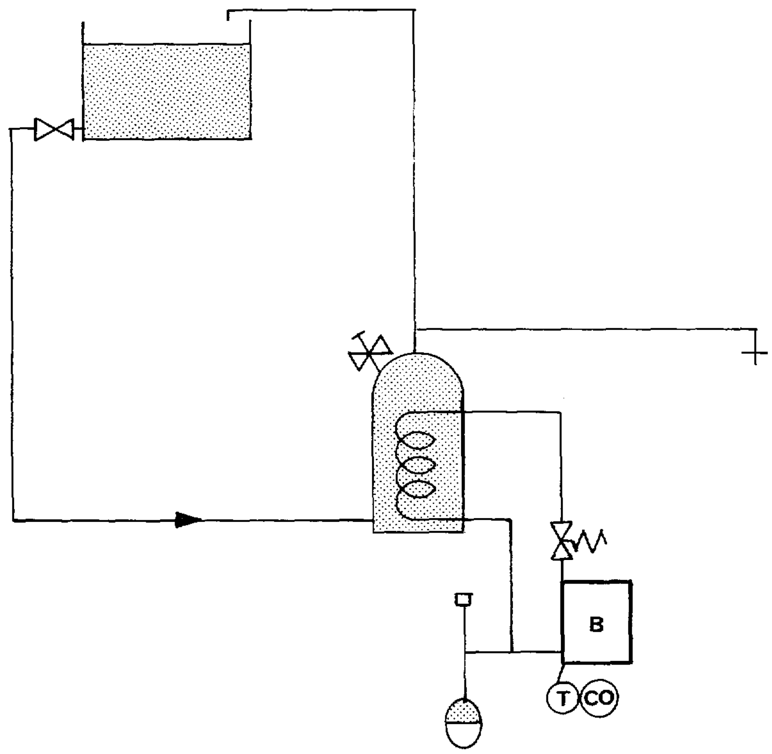
Vented water heater provided with:

i. thermal relief valve (set below or close to 100°C).

Case 4A



Case 4B



Case 4C

Gas or oil fired domestic boiler in a sealed primary circuit providing heat to an unvented storage heater.

Primary circuit provided with:

i. thermostat,
ii. energy or fuel cut-out (set at or below 90°C),
iii. pressure relief valve, and
iv. air or gas loaded expansion vessel.

Secondary system provided with:

i. thermal relief valve,
ii. pressure relief valve, and
iii. thermostat (if operating temperature of hot water for use is lower than the operating temperature in the primary circuit serving space heating).

Case 4D

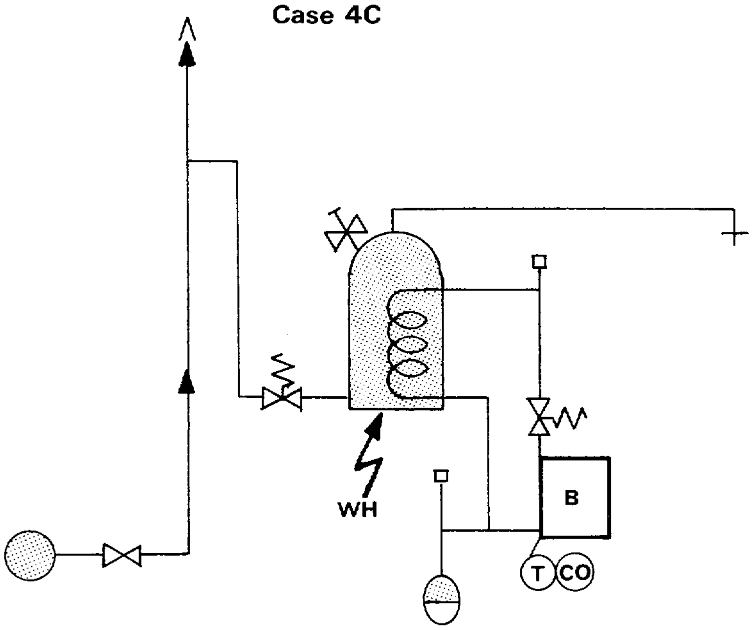
As Case 4C

Primary circuit, as Case 4C but energy or fuel cut-out set at or below 100°C.

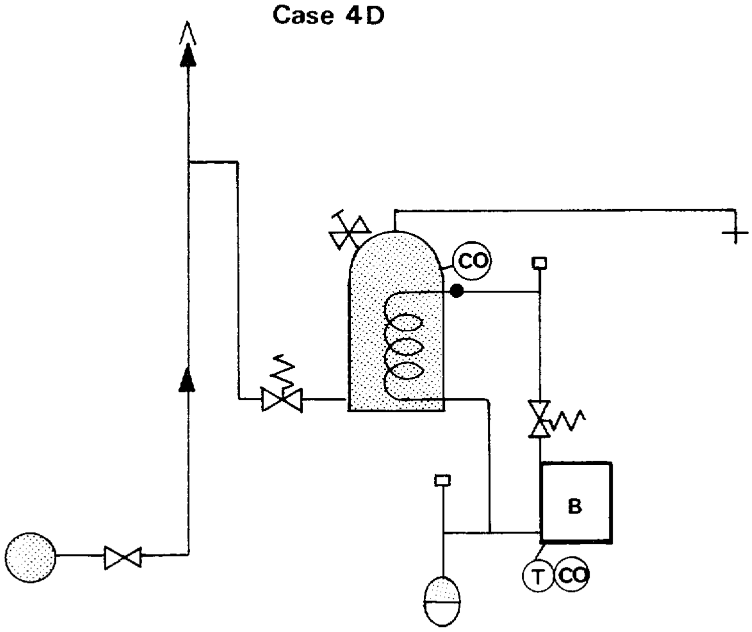
Secondary system provided with:

i. thermal relief valve,
ii. pressure relief valve,
iii. energy or heat cut-out (set at or below 90°C), and
iv. thermostat (if operating temperature of hot water for use is lower than the operating temperature in the primary circuit serving space heating).

Case 4C



Case 4D



Case 5A

Single unit mains fed water jacketed tube heater with an unvented hot water reservoir as heat source.

Primary circuit provided with:

i. electric immersion heater with thermostat and energy cut-out,
ii. thermal relief valve,
iii. pressure relief valve,
iv. pressure reducing valve (non-backflow type), and
v. sealed expansion vessel (if hot water reservoir is not 'bubble top' type).

Secondary system – no measures necessary (providing backflow is not prevented).

Case 5B

Multiple units mains fed water jacketed tube heaters with unvented hot water reservoirs as heat sources.

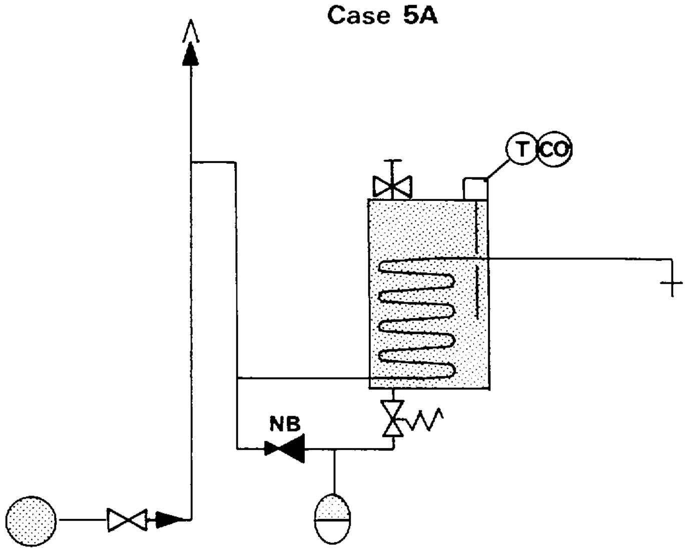
Primary circuit no. 1 – as primary circuit in Case 5A except check valve instead of pressure reducing valve.

Primary circuit no. 2 – as primary circuit in Case 5A.

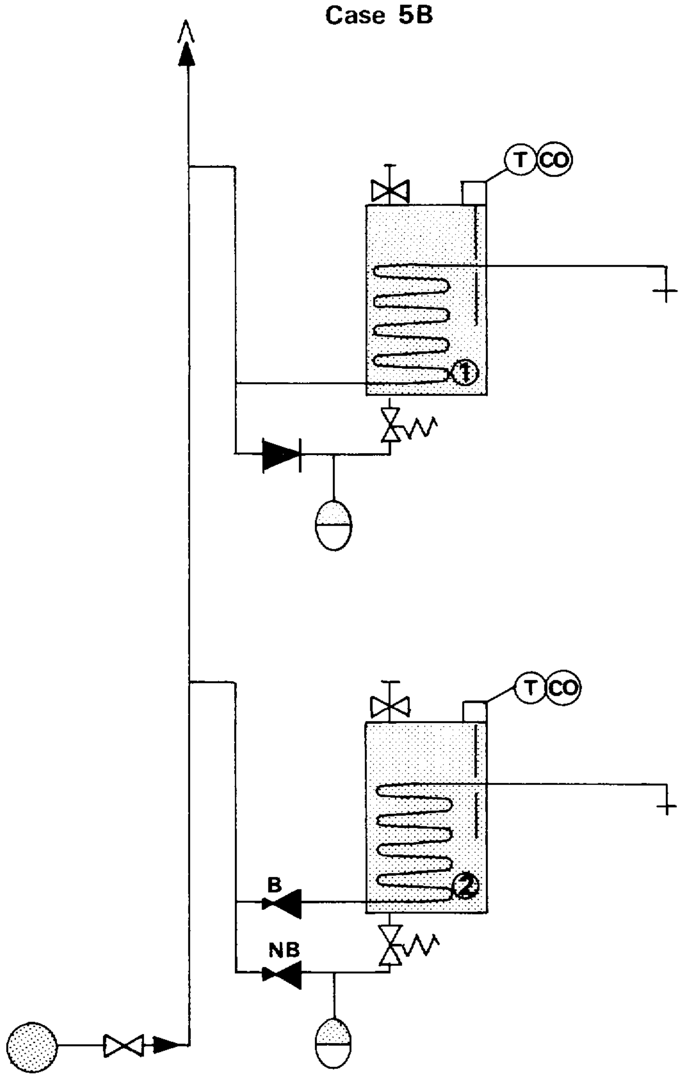
Secondary system no. 1 – no measures necessary (providing backflow is not prevented).

Secondary system no.2 – pressure reducing valve provided (backflow permitted type).

Case 5A



Case 5B



Case 5C

Single unit mains fed water jacketed tube heater with an unvented hot water reservoir as heat source; reservoir heated by an independent gas circulator.

Primary circuit provided with:

a. gas circulator
   i. thermostat,
   ii. energy cut-out,
   iii. thermal relief valve, and
   iv. pressure relief valve.
b. Unvented hot water reservoir
   i. check valve on cold water inlet, and
   ii. sealed expansion vessel.

Secondary system – no measures necessary (providing backflow is not prevented).

Case 5D

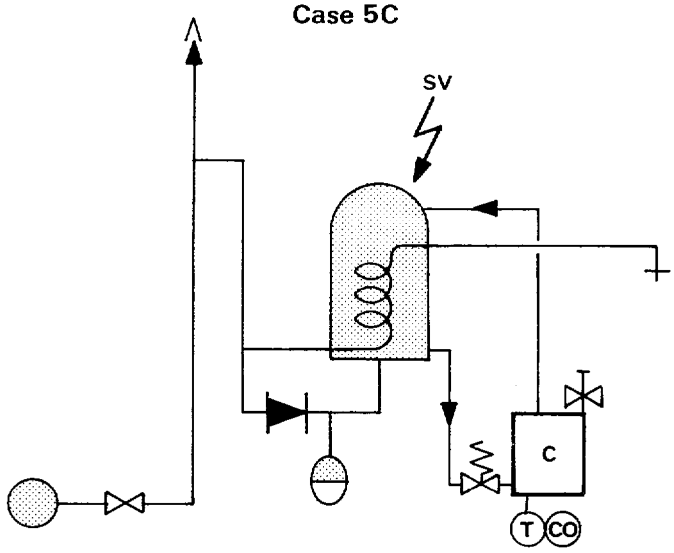
Single unit mains fed water jacketed tube heater with an unvented gas circulator integral with hot water reservoir.

Primary circuit provided with:

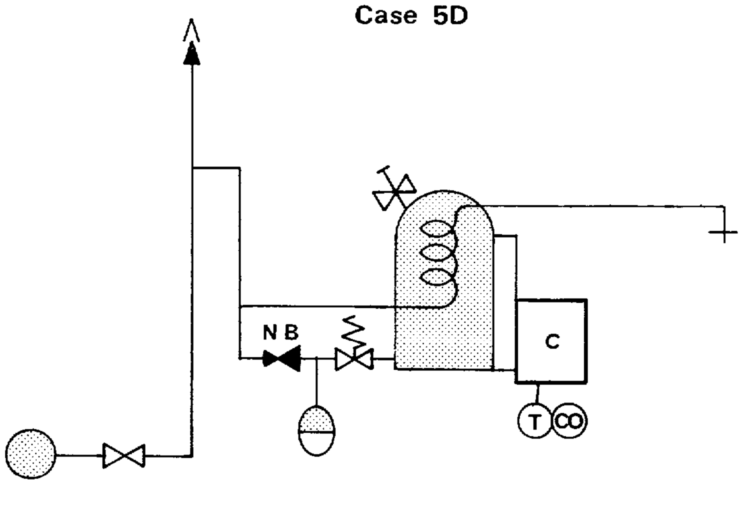
i. thermostat,
ii. energy cut-out,
iii. thermal relief valve,
iv. pressure relief valve,
v. pressure reducing valve (non-backflow type), and
vi. sealed expansion vessel.

Secondary system – no measures necessary (providing backflow is not prevented).

Case 5C



Case 5D



Case 6

is indicative only of the permutations of systems which are possible. The 3 installations shown could be supplied from either cistern or mains.

Each water heater is provided with 2 independent methods of heating. In each mode of operation, the water heaters are shown with their pressure relief valves, thermal relief valves and the sources of energy or heat input have thermostats and cut-outs. The sealed primary circuits are also provided with pressure relief valves and sealed expansion vessels. When necessary, the associated water heater thermal relief valves could operate to protect the primary circuit.

Case 6