Discussion

The Chairman (Mr W. A. M. Allan) said that the disposal of radioactive wastes, which he thought the Authors would agree was still to a certain extent in its infancy, was of particular concern to public-health engineers from two points of view. One was that of those interested in the production of drinking water; at present radioactive elements were discharged into rivers and streams eventually used for water supply. The second was that of those interested in the disposal of sewage, who were particularly concerned with that problem, because disposal of radioactive wastes from hospitals, commercial laboratories, and industries would increase. As a result trade wastes which might possibly contain radioactive materials would be discharged to the sewers; although at the moment the quantity was small and the effects negligible, that might not always be so, and serious consideration might have to be given to that type of trade waste in the future.

He had been struck by what the Authors had said about collaboration. That was very important in all public-health engineering work and he had been very glad to read the Authors' statement that "many of the problems could best be developed by firms working in allied fields. . . . These firms were given basic principles to develop or, alternatively, were associated with current research". As a result of what might be called the working party so formed, which had included the manufacturers as well, the plant at Aldermaston was probably the best of its kind for the work which it had to do. Engineers who had to carry out such works often failed to take into consideration the vast experience which the manufacturers possessed in their own field, and which could be very useful.

He had been unable to find in the Paper any record of the daily quantity of sludge produced. That was of great interest to those concerned with sewage works. A great deal of research had still to be done in the sewage-treatment world to find a cheap and easy method of disposing of sludge. Engineers working in atomic establishments might find the answer to that problem. What had happened to the experiments carried out at Harwell on the freezing process for reducing the volume of sludge to be disposed of? Had they not been found practicable, or had the method been found too expensive?

Reference had been made to the necessity of diluting the effluent before it entered the river, and it appeared that mains water was used for the purpose. The Chairman was not familiar with the exact route of the discharge mains, but understood that they ran through or near a sewage works. Had consideration been given to the use of sewage effluent for the purpose?

Mr C. D. C. Braine (Partner, Messrs G. B. Kershaw and Kaufman, Consulting Engineers) said that in view of the considerable difficulties in the disposal of active sludge, the design of the sedimentation tanks was surprising. Each tank might have been expected to have a comparatively large central hopper in which the sludge scraped to it could consolidate before being drawn off; instead the Figures seemed to show a small hopper from which it would be difficult to draw sludge without "funnelling" occurring. The sludge, he thought, would not be liable to biological action; consequently it might be left in the hopper for 2 or 3 days before it was drawn off. On one job with which he had been associated some experiments had been made with ordinary sewage sludge to see what would happen. A rectangular tank with deep hoppers was used and when sludge was drawn off, for the first few minutes it had contained 89–90% of moisture, but after about 5 min, because the sludge did not slide down the hopper fast enough, water began to reach the outlet. Within 15 min, long before the hopper had been emptied, the sludge obtained had a moisture content of about 97%. If the sludge valve was then closed and the hopper was left for a quarter of an hour, the sludge began to level out again, and on re-opening the valve, sludge with a moisture content of about 92% was obtainable.

Because the sludge at Aldermaston was so light, he would have expected the sludge scrapers to be of the continuous-blade type with a peripheral movement far slower than was common in much larger tanks used for sedimentation of sewage. Even in those larger tanks, peripheral speeds of 4 ft/min were about the limit if eddying round the scraper blades was not to occur. The speed at Aldermaston seemed extraordinarily high. On the basis of 4 ft/min the corresponding speed in the small tanks used at Aldermaston would have been about 0·6 ft/min. Considering the lightness of the sludge, the speed at which the scrapers were operated was about ten times what he would have expected.

The safety precautions taken everywhere on the Aldermaston plant seemed extreme. It would be interesting to have an insurance expert's view on what premium should be paid on the plant as designed, and the premium if certain precautions had not been taken. There must be an economic limit beyond which it was unprofitable to go. He wondered whether he was right in supposing that at the present time all concerned with atomic wastes were being extremely cautious and were therefore taking every precaution, but that probably in 10 years' time, when more knowledge was available, perhaps half the present precautions would be dropped. From the point of view of a manufacturer using radioactive substances in a typical industrial plant, would it be practicable or possible in such a plant to take safety precautions on the scale adopted at Aldermaston?

During part of the 1939–45 war he had commanded a bomb-disposal company. For the first few weeks everybody had been extremely careful when handling bombs, etc., and all reasonable precautions had been taken, but when the men had become accustomed to the work, the problem arose of ensuring that they took proper precautions. If, when dealing with high explosives, the hazard of sudden death was not a sufficient deterrent to prevent carelessness, what would happen when dealing with radioactive materials causing only a lingering death, the signs perhaps not showing themselves for 10 years? In such circumstances, would it be possible to control the workers properly, or would it be necessary to employ scientifically trained people who would appreciate the serious risks of carelessness?

At Aldermaston, the active sludge wastes were disposed of in steel canisters which, encased in concrete, were dumped into the sea. In that connexion, he had recently been informed by an American delegate to the Nuclear Conference at Geneva that the problem of disposal of active wastes in America was regarded very seriously. Mr Braine had asked, more or less jokingly, what was wrong with the Atlantic for that purpose, and the reply had been that the Atlantic Ocean was not nearly big enough for what they expected to have to deal with shortly. The American had added: "You live at the receiving end of the Gulf Stream, and moreover if we use the Atlantic we may contaminate the fishing banks around Newfoundland, so there is a limit to what we can dispose in the Atlantic". Apparently it was not going to be possible to use the sea or the land, so that all that was left was the heavens! It had been suggested that the material would have to be shot up into the sky and become a satellite going round the earth. What did the Authors expect to do when they had big quantities of active wastes coming from large plants in, say, 10 years' time?

Mr W. Fillingham Brown (Consulting Engineer) remarked that he had not sufficient knowledge to criticize the design of the plant in detail, but had been wondering if the techniques described in the Paper might be applied to ordinary sewage-treatment processes, and particularly to those of chemical precipitation and mechanical flocculation. Chemical precipitation recently appeared to have suffered an eclipse in sewage treatment, and whilst mechanical flocculation had been tried, it did not seem popular. The success of the plant at Aldermaston did raise the possibility—although of course that plant was on a very much smaller scale than most sewage-treatment plants—of applying those methods to sewage-treatment processes to improve sewage-works effluents, in view of the present-day trend towards a higher standard of effluent. He thought there was a possibility of a higher degree of removal of solid matter, perhaps by mechanical flocculation, with or without chemical precipitation.

He had been interested also in the way in which the normally used and well-tried methods adopted at Aldermaston had been applied in what might be called a mechanical-engineering or chemical-engineering rather than in a purely civil-engineering manner.

The reasons were given in the Paper; one had been lack of time and another the necessity of detecting and containing possible leakages, but he wondered how the cost of maintenance would compare, over a period of years, with more orthodox civil-engineering applications.

The costs given at the end of the Paper were particularly useful, and the Authors were to be congratulated on including them, particularly because the plant was of a new type.

In the flocculation tanks provision was made for flow to be either upward or downward. How was it determined which way the flow should be directed, and did either give a better result than the other?

Would the high efficiency obtained—by ordinary standards it was of course extremely high, with a reduction of 99·9%—be maintained, particularly if the effluents varied at all from those at present, or was the type of plant at Aldermaston such that the Authors foresaw little or no variation in the type of effluent to be dealt with?

Mr R. W. Querée (Chief Engineering Assistant, Finsbury Borough Council) referred to some problems in the disposal of radioactive effluents, though not of the type described by the Authors or arising from the Paper.

There were many problems in municipal engineering right from the origin of the waste in a factory, laboratory, or other building, which might be situated in the centre of a town, and the municipal engineer had to deal with waste from its origin to its disposal. The Paper provided some thoughts on disposal, but the problems dealt with by the Authors would not arise in towns for some time to come; therefore perhaps they might be able to deviate from the subject a little and give some advice on the desirable limits of radioactivity so far as discharge to public sewers was concerned. That was causing a good deal of interest at the moment. He had in mind the discharge of active effluents through the normal drainage system, which might involve harm to occupants of buildings and to people in the streets from activity under the ground. It was also necessary to consider the men who worked in sewers, where the effluent was mixed with the sewage.

What concentrations did the Authors consider were permissible in a sewer, and could they also give some guidance on concentrations at treatment plants? He had seen published recommendations that the maximum should be 5 μc per flush and 50 μc per week per institution. He would also appreciate guidance on the storage of radioactive wastes in densely built-up areas. He had in mind factories which produced such wastes and wished to discharge them into the sewers. Some comments on the desirability of authorities being able to insist on storage or making provision for it would be very useful.

He would also welcome comments on the possible effect of those effluents on existing types of sewer. At Aldermaston, where the problems were special, stainless-steel pipes were used. Normally in sewage disposal salt-glazed stoneware or concrete were used for pipes. There had already been trouble in concrete pipes when acids were discharged. Problems were also met with in brick sewers. It seemed to him improbable that local authorities could ensure the removal of radioactive materials from effluents even from large factories.

Mr R. H. Burns (Chief Industrial Chemist, A.E.R.E., Harwell) said that on p. 626 it was not made clear that the tolerances given applied only to the Thames. In fact they were special figures, on an average one-hundredth of the internationally accepted drinking-water tolerances for occupational workers. The Thames figures had been recommended by the British Medical Research Council to afford complete protection to the public of London. The figures given were for the activity permissible in the Thames after any radioactivity had been added; they did not apply to the effluent itself.

The next point was that for the sake of accuracy the references in the Paper to the "Ministry of Health" should be deleted and "Ministry of Housing and Local Government" substituted.

On p. 627 it was stated that some of the drainage systems at Harwell were not fitted with control systems. To prevent any misunderstanding it should be emphasized that that was not now the case and all were now under strict control.

On p. 636 and subsequently the Authors had given figures for activity removal ranging from 93% up to 99·9%. It should be realized that that referred to alpha activity only. Where mixed beta activity was also present, as at Harwell, the efficiency of removal could not be so high.

Referring to the use of demineralized water within the Establishment, Mr Burns suggested that one of the main reasons for that requirement was the much smaller bulk of sludge produced during the chemical treatment of radioactive effluents. Since the chemical sludges were disposed of at sea the cost of demineralization was soon recovered. It was not clear to him how it was possible to measure alpha activity without evaporation as was suggested on p. 638 but possibly Mr White could explain the technique.

A statement made on p. 649 might give the impression that the discharges from Harwell and Aldermaston were related to the extreme dry-weather flow of the Thames. That was not so, as agreement had been obtained to use the harmonic mean flow of the river at the various discharge points for dilution of the effluents.

On p. 651 mention was made of cathodic protection but there was no reference to the possible use of magnesium electrodes. Had that been considered and if so, why had it been rejected?

Mr Burns hoped the Authors would not mind if he answered the Chairman's question on the freezing plant at Harwell. That plant had now been installed and the acceptance tests had been carried out. They had given very favourable results and although the plant was in its early days it appeared that a 50% reduction in sludge volume could be expected. If that was realized, even ignoring the great increase in filtration rate and other advantages, the saving involved would pay for the plant in about 12 months.

Mr S. H. Lewis (Senior Engineer, Messrs G. B. Kershaw and Kaufman, Consulting Engineers) said he would like to ask the Authors about their views on time factors. It had been stated that the plant in question had been built to permit important atomic experiments to proceed, only 5 years ago. (As an aside, he would suggest that the atomic bomb was the devil that drove.) A period of 10 years had been suggested as that during which industrial uses of radioactive materials might become far more widespread, and as a result there would be industrial effluents which would contain intolerable amounts of active material. Should the excellently designed plant at Aldermaston be regarded as a pilot plant for one which might have to be produced on ten times the scale within an average lifetime? If so, were materials such as stainless steel and the alloys referred to absolutely essential? It appeared that cost of effluent disposal would be a limiting factor if that were so.

It had been emphasized that water-treatment plant technique was the basis of the successful production of the effluent discharged to the Thames. That seemed to him essential, because having regard not only to Aldermaston but to other similar establishments, he imagined that the build-up of radioactive material in streams which were already, or became, sources of potable water must be a serious problem. That brought him back to his original question about the time factor. For how long would it be possible to tolerate such a build-up as would arise from peaceful, industrial uses, or other uses, which produced similar effluents?

Dr K. J. Ives (Lecturer, Department of Civil Engineering, University College, London) said that most of the speakers had shown their interest to be in relation to their experience of sewage works. His own experience lay in water purification and in the operation of three different types of upflow units, similar in principle to those employed at Aldermaston. He wished to speak on sludge treatment. On p. 636 the Authors had said that "a high price can be afforded for treatment chemicals which give an appreciable reduction in sludge volume". Increasing use was being made in the water industry of a chemical-activated silica, which reduced the quantity of sludge to be treated. It added to the cost, in that it was a reagent, but the reduction in volume it brought about might make that extra cost worthwhile. In his own experience, which had been with the use of aluminium sulphate, the use of the activated silica as a coagulant aid had reduced sludge volumes quite considerably with three types of clarifier.

He could give some typical figures. A dose of 60 p.p.m. of alum in an Accelator gave an average volume of sludge of 0·9% of the water treated. When 10 p.p.m. of activated silica was added, that was reduced from 0·9% to 0·4%, or just under half. Operating with a cylindrical clarifier, with a dose of 100 p.p.m. of alum, the volume of sludge had been 6·9%, and by adding activated silica that had been reduced to 3·3%, or again just under half. On another occasion, when the water temperature had been different—which affected the volume of sludge—4·4% with alum alone had been reduced to 0·6% by the use of activated silica, which was quite a substantial reduction.

Lastly, using a hopper-bottom clarifier, similar to that described in the Paper, with an alum dose of 20 p.p.m. the sludge volume was reduced from 3·8% to 1·2% by adding 2 p.p.m. of activated silica. Had the Authors considered the use of activated silica when discussing the use of aluminium sulphate coagulation at the outset of their experiments? He did not know whether activated silica had any application to the tannic-acid-lime process, and would be glad of enlightenment on that point. An additional advantage of the silica was that it gave mechanical strength to the floc, which was less likely to be broken by turbulence or shear in the water. That might be of advantage in the Authors' plant.

In the operation of a conventional water-treatment plant he had found it an advantage to pass the sludge from the clarifiers first to sludge-settlement lagoons, where the sludge fraction settled under completely quiescent conditions, with no flow, and the supernatant water could be pumped back for retreatment and the thickened sludge then taken away for further treatment.

Mr J. P. Asquith (Manager, Engineering Division (Projects), W. J. Fraser & Co. Ltd) said that in the Paper there were two references to the Harwell experience: first, where contamination had occurred in streams where it had not been expected, and secondly, concerning effluent limitation where the various devices of recirculation and limitation on water usage were mentioned. It seemed to him that basically the less effluent produced in the first place, the easier the problem was made in magnitude throughout. He would like the Authors to elaborate a little therefore on just how far it was possible to go in the reduction of the total size of the problem by a bigger internal re-use of water so that the problem never got outside.

Mr F. E. Ireland (Inspector of Alkali, etc., Ministry of Housing and Local Government) wrote asking whether the type of tannic-acid-lime precipitate was important for the efficient removal of the radioactive constituents. In other words, would a denser more crystalline precipitate be just as effective as the light flocculent precipitate now being obtained?

Did the precipitation conditions follow von Weimarn's theories of precipitation and were they taken into account when designing the treatment plant? In general, particle size was proportional to the degree of dilution of the reactants and inversely proportional to the viscosity. Regarding dilution, could a denser precipitate be formed by back-mixing some of the treated effluent from, say, the flocculent tank with the treatment chemicals before addition to the flume mixer, or better still, by designing a continuous mixing vessel whereby the reactants were added at diagonally opposite points and received adequate dilution by the product before they met? Viscosity could be lowered and settling aided by heating the reactants, and he wondered whether waste steam was available for keeping the effluent warm in the pretreatment storage tanks. Using those techniques it was possible to produce crystalloid-type precipitates of greater bulk density and holding less entrained water than many gel-like precipitates formed by more conventional methods of precipitation.

Mr White, in reply, said that reference had been made in the Paper to the consideration given in the design to the probable use of citric acid as a decontaminant. So far as their knowledge had gone at that time, citric acid was the most likely decontaminant to be used. However, the Paper would become out of date if it were not stated that much research had been since done on decontaminants, and far more modern methods were now used. Nevertheless, the principle of having separate collection lines for liquors which contained decontaminants was sound.

A point perhaps not sufficiently emphasized in the Paper was the degree of automatic control possible in the chemical-treatment plant. Provided that all the services were in operation—chemical, electrical, and demineralized water—it was possible by a single throw of a switch to start a complete section working. Automatic control was optional, and the plant could be operated manually at all points, either if the automatic system failed or for testing individual units.

Control was exercised over the movement of effluent to ensure that a number of checks were made between discharge from buildings and discharge from site, and so that any particularly high activity discharge from a building could be specially segregated or treated instead of being allowed to raise the general activity level of the plant. The delay tanks outside individual buildings were sampled and analysed for radioactivity before a "Move" certificate was issued, and no pumping took place from such tanks until the certificate was issued. Much complicated paper work was involved, but they hoped in the near future to speed it up by the installation of a facsimile transmitter from the laboratories to the movement-control office. At the bulk-storage area a similar procedure of radioactive analysis before authorizing movement was adopted and the level of activity determined.

At the pre-Thames-storage stage a sample was taken and divided into five parts. One went to their own laboratory for radioactive check, a second to their own laboratory for the ordinary trade-wastes check, a third to the Establishment's Health Physics Branch, the scientists of which were finally responsible for ensuring that the activity level was satisfactory. The fourth went to the Ministry of Housing and Local Government for a radioactivity check and the fifth was kept in the Establishment as a reference sample. Finally, continuous samples were taken at the point of discharge to the Thames and checked for radioactive content and for the way in which they met normal trade-waste requirements.

The Aldermaston plant had now been in operation for about 4 years, and it might be of interest to consider the extent to which the performance of the plant had come up to design expectations. First—and that partially answered one of the questions raised in the discussion—the plant had handled successfully all radioactive effluents from the Establishment without once exceeding the permitted tolerance level—and there had been a variety of types of effluent certainly not expected originally, including even small amounts of beta and gamma effluents, which, as Mr Burns had pointed out, could not be treated with the same high efficiency in such a plant.

Total activity discharged to the Thames had been no more than one-third of that acceptable to the authorities, even though the basis of the tolerances was extremely conservative. The plant's efficiency had been maintained at 99·9% whenever the activity had been high enough to need that, although the normal level of activity discharged was very low and a working efficiency of about 99·7% was usually obtained.

The average sludge volume to be disposed of at sea was about 0·2% of the treated effluent, appreciably better than the figure obtained in pilot-plant studies. That probably answered the Chairman's question about the quantity of sludge disposed of. Mr White had done a rough calculation based on the amount treated, and using that figure, it came to 15 gal/week. That might also answer the question on the smallness of the hopper in the bottom of the thickeners, because the amounts of sludge with which they were concerned were extremely small, and the small pits at the bottom of the clarifiers held a week's sludge or even more. In the thickeners, unless care was exercised, the sludge became so thick that it could not flow reasonably into the can unit. It seemed, therefore, that no modification was required so far as the final collecting was concerned.

The total rate of effluent discharged had gradually increased until it now averaged 20,000 g.p.d., which was getting near the calculated discharge rate given in the Paper of

25,000 g.p.d. In general, therefore, it would be agreed that the actual performance had matched the design expectations.

Mr Burns had answered the Chairman's question about the freezing process adopted at Harwell for reduction of the volume of sludge. At Aldermaston an alternative method of reduction of the sludge by evaporation had been developed, in which the cans in which the sludge was discharged were taken and use was made of the very efficient ventilation system to evaporate some of the water, to increase the solid content, which was only about 9%. One drum could therefore take a successive number of discharges of sludge, so that the total volume of material to be disposed of was considerably reduced.

On the question of to what extent the precautions at present taken in the plant might be dropped now that more experience of radioactivity had been gained, Mr White hesitated to give an answer except in very general terms, because it would be appreciated that it was a subject on which the Atomic Energy Authority was constantly engaged. They could not spend public money to any greater extent than was essential. It was mainly a question of engineering to the tolerances clearly laid down by the medical experts. If they were told that certain concentrations were allowable in the air and certain others in the water, it was only straight engineering to ensure that those tolerances were observed. They had had experience in the Atomic Energy Authority of where, if precautions were relaxed only slightly, they began to get far too close to those tolerance levels. They found very often that they were working to a nice balance in just ensuring that they met the figures laid down by the health authorities.

It had been asked whether the efficiency of the plant was being maintained. He had already mentioned that an efficiency of 99·9% was being maintained whenever that was required.

Mr Burns was right in suggesting that the emphasis on the use of demineralized water was a matter of reducing as far as possible the amount of sludge obtained from the water-treatment plant. All the dissolved solids in the water were likely to come out in the sludge. The point they had intended to make was that the accuracy of measurement by the evaporation method was lessened if there was a large quantity of solids which came out in the evaporated sample, and that accurate control was therefore more possible with demineralized water being generally used.

They had toyed with the idea of using activated silica, but having regard to the very small quantities of chemicals used they had concluded there was no likely advantage from its use, although they were well aware of its advantages. They were, however, very interested in the figures advanced by Dr Ives; that was a point which might deserve re-examination.

In regard to Mr Ireland's remarks, although little was known about the effect of the physical type of precipitate on radioactivity removal, Mr White would not anticipate that a more crystalline precipitate would be a disadvantage.

The use of dilution as a means of achieving that, however, would not be likely to be successful as radioactive removal was certainly less efficient at lower concentrations. Heating the liquid to reduce the viscosity had been considered, although there was no waste stream available, and had been dismissed partly on cost grounds but also because it had been found that minor temperature variations (if only a few degrees) in the flocculating vessels were sufficient to cause convection currents which seriously upset the settlement of the floc.

Mr Milton, in reply, said that it had been evident that there were water engineers present at the discussion who, he was sure, were very appreciative of the use made of the orthodox pattern of water treatment. They knew the difficulties in treating the complexity of highly alkaline coloured water, inasmuch as very great care had to be taken with pH control when forming the floc, and the measures necessary to preserve the floc from its formation to its subsequent settlement or deposition on filters. The handling of the floc had been a major problem in the design of the Aldermaston effluent-treatment plant. The Paper indicated that the rate of treatment had been considerably slowed down from the orthodox pattern. In the orthodox method the time for settlement after chemical treatment varied according to the content of the raw water from 1 to 2 hours, but at Aldermaston settlement took 10 hours. Again, the orthodox speed of filtration was about 80 gal/sq. ft/hour, whereas at Aldermaston it was 26 gal/sq. ft/hour. The normal velocity through pipes in water-treatment plants was 2–3 ft/sec, whereas at Aldermaston that velocity was about 0·25 ft/sec.

Ways and means would obviously have to be considered on future plants to reduce the cost of treatment per thousand gal. The experience gained from Aldermaston would, it was hoped, give an indication of the avenues along which that could be brought about. He felt that the present Paper, and the two earlier Papers (references 2 and 3 on p. 655) could be of considerable assistance to many engineers who were bound to have to deal with radioactive effluent problems as the scope of atomic engineering widened in the industrial field. In answer to Mr Allan's question on the use of sewage for dilution, it could only be said at the present time that provided that the River Board concerned would accept the sewage effluent into the river there appeared to be no objection to the effluent being used for that purpose, the qualification being that it would have to be entirely free from suspended matter. However, that was a subject for further research work.

Mr Wilson, in reply, said that collaboration with industry had been undertaken for the great specialist knowledge which the Ministry did not possess. It was to be a wise technique.

The dilution effected prior to discharge was purely to increase the mass of water entering the river in order to effect good distribution in it. The effluent rate was about 50 g.p.m., and to distribute that quantity in the river would have meant small nozzles or some similar technique which might have been affected by river silt.

They had given serious thought to the limitation of costs of effluent-treatment plant. However, Harwell, Aldermaston, and Windscale were the first plants of their kind, and it would be very foolish to hamper a new science by having an accident through not being careful. They had therefore erred on the side of safety, and he thought that they had been right. Nevertheless, they did continually in that and other fields, when opportunity offered, derate materials and there had been a movement from stainless steels, of which there had appeared to be a need in the early days, to plated and painted mild steel. They did not derate, however, at the expense of running any risk.

The disposal of materials at sea was a subject on which he could not speak with authority, and he must leave that to others.

The Authors had quoted advisedly the operational costs given in the Paper. They could not be said to be completely accurate; perhaps they should be modified a little because obviously in the figures quoted there were acceleration costs, because the work had had to be done quickly. There was also rather a long pipeline, which not every plant would require. The quoted design figure per gallon of effluent was related to less than 24 hours per day, so that the price per gallon could be reduced. It would still be a high price per gallon, however, and that was the point which they wanted to bring out.

Mr Querée had raised some very interesting points on the subject of tolerances in public sewers and the like. Mr Wilson did not feel himself competent to comment on those issues. Much more would of course be published on the subject as time passed. Mr Querée's points about the effect of radioactivity on pipes and the use of various materials was a subject on which a great deal could be written.

The Authors were glad that Mr Burns had been able to take part in the discussion and put the question of tolerances in its right context. They would all be very wise, when they read of a tolerance in such a Paper as the present one, not to think of it merely as a figure but to have regard to its background. Mr Wilson was also glad that Mr Burns had made it clear that there had not been any failure at Harwell on the non-monitored pipeline. The deficiency in the system had been dealt with before any trouble arose, as he believed was mentioned in one of the previous Papers.

Mr Asquith raised the question of the conservation of water to reduce the quantity of effluent so far as possible. The techniques possible for that purpose depended on the type of process in use. Whenever they were dealing with a prospective radioactive effluent they went to considerable lengths to reduce the quantities to the absolute minimum, and when the plant was working the operators did all that they could to achieve the same end.

Finally, the plant had been designed against the particular needs of the Aldermaston establishment. It should not be assumed that such plant was a necessity at every atomic energy establishment; indeed for the atomic energy power stations now being built very little was required, inasmuch as the radioactive arisings would normally be small.

The important aspect of the Paper was the fact that relatively normal water-treatment plant could contain and precipitate active effluents of the type under review.