Mr. Clark reports success in compensating for some of these conflicting priorities by moving the secondary chamber to a location above the primary combustion zone. It is an interesting design development and one which merits consideration.

DISCUSSION by B. B. Reilly

Mr. Clark has presented an interesting review of a number of incinerator furnace enclosure arrangements for chute fed, bulk grate, refractory lined furnaces. In his evaluation of these arrangements, Mr. Clark has used such matters as heat release rates, gas velocities, and grate loading. Perhaps broader and more basic criteria should be considered such as:

1. Maximum residue burnout
2. Maximum completion of combustion of gases
3. Minimum particulate loading at furnace exit gas (for effectiveness of air pollution control device)
4. Minimum excess air in exit
5. Minimum maintenance requirements
   (a) Refractory slagging, erosion, spalling, etc.
   (b) Grate wear, clinkering

These functional requirements do not necessarily benefit from similar design or operating conditions such as furnace temperature or gas velocity. Residue burnout and completion of combustion of gas are improved by higher temperature and increased turbulence, or gas velocity. However, particulate loading increases with turbulence, and maintenance increases with furnace temperature. Increasing the excess air ratio tends to assure maximum combustion of the furnace gases, but increases air pollution control problems as well as limiting heat recovery potential.

There seems to be an endless series of opposing requirements so that furnace design becomes, to some extent, a matter of establishing priorities and then compensating in some fashion for necessary compromises.

DISCUSSION by M. Dvirka, P.E.

The author addressed the problem of furnace design in terms of “flue gas” (products of combustion) velocities, exclusively.

Not once in the entire paper is mention made of the most important parameter in furnace design, the heat exchange in a furnace cavity.

The author would be well advised to review the 1968 and 1972 ASME National Incinerator Conference Proceedings papers entitled “Temperature and Air Distribution in Large Rectangular Incinerator Furnaces.”

He would find that the problems of gas stratification and very uneven temperature distribution, inherent to furnace configurations shown in Figures 1, 2, and 5, have been well defined.

In one instance the author mentions the fact “that lower velocities and better performance might be obtained where there is a drop in the roof arch to retain the burning gases within the furnace enclosure.”

Nevertheless, this “advantage” has been ignored by the author in the design of the Washington, D.C. and Baltimore, Md. plants.

The furnace configuration, proposed by the author as the “ultimate” in refuse burning furnace
design, offers fairly uniform gas velocities throughout the combustion zone. There is no mention, however, about the combustion chamber heat exchange and utilization of the released energy to provide for efficient combustion of a fuel with wide variations in combustion characteristics, especially wide variation in moisture content, such as municipal refuse.

The discussion of the furnace configuration shown in Figure 3, does not mention, at all, the fact that most installations of this type have experienced severe problems due to localized high temperatures and slag formation. In several instances the reflecting arches had to be removed and the combustion air distribution changed in order to be able to operate the plant safely near its original design capacity.

As to the furnace configuration shown in Figure 6, several comments are in order. It is similar to a boiler burning anthracite coal and with low volatile and high fixed carbon content.

With high volatile content fuel, and especially refuse, the "combustion" volume under the long rear arch is almost completely wasted, as experienced on the Washington D.C. and Baltimore, Md. plants. Most of the burning takes place under the vertical furnace shaft, resulting in localized high heat release, excessive temperatures and serious slagging problems in the lower portion of the furnace.

If the combustion air distribution is not carefully controlled, slagging in the upper part of the vertical furnace shaft must be expected as well.

It is difficult to understand, even with the Washington, D. C. and Baltimore, Md. experience, that the Figure 6 furnace configuration is presented as an advance in refuse burning furnace design.

**AUTHOR'S REPLY**

The discussors seem more interested in justifying their conventional approach to incineration than in accepting the fact that many refractory incinerator furnaces of conventional design operate with incomplete burnout of the residue and of the combustible products in the flue gas stream, thereby contributing substantially to the pollution of our environment. This reply is directed to the general tone of the discussors comments rather than a detailed reply.

The furnace configuration, Figure 6, was first applied by this author to a refuse fired refractory furnace design in 1967. However it is not considered to be original or the "ultimate" in furnace design. The first similar application was at the continuous feed traveling grate furnaces in the original Betts Avenue Plant Design for New York City. The charge hopper configuration of those furnaces (approximately 8 feet square) is reported to have acted as a better stack than the exit flue. As a result, rather than modify the flue design to provide the necessary draft, the charge hopper was redesigned and the furnace exit relocated to provide a design similar to Figure 1.

A configuration similar to Figure 6, was presented in 1966 by L. J. Cohan in a paper titled "Flow Studies by Water Table Technique for Incinerator Furnaces" (Reproduced in ASME Publication "Incinerator and Solid Waste Technology"). This configuration was subsequently used for a large municipal incinerator in one of our southern states. Problems that developed downstream of the furnace have prevented an evaluation of that installation.

It is this writer's opinion that the methods used to develop the configuration shown in Figure 6 result in a furnace with a relatively uniform heat release rate per unit of furnace volume. This can be visualized by comparing Figure 6 with Figure 5 of M. Dvirka's paper on Practical Application of Incinerator Burning Rate Equations on page 556 of these 1976 Proceedings. This configuration reduces the tendency to develop "hot spots" with resulting slag problems. It also limits the requirements for excessive overfire air to control "hot spots" permitting more efficient combustion and providing a potential for better energy recovery.

The reviewer's attention is also directed to modern water wall steam generating units for bagasse, bark or refuse firing where similar furnace configurations are predominant.

Slides displayed during the presentation of the paper clearly indicated the excellent quality of ash residue obtained at the Baltimore facility with the Configuration of Figure 6. This combined with the lack of visible emissions from the stack clearly demonstrates that complete combustion is being obtained. Washington, D.C. has completed several years of satisfactory operation with this design, likewise Baltimore, which was started on July 10, 1975 and is now completing its first year operating continuously above capacity.