Proceedings of the 4th National Conference

Evaluating The Fluidized Bed Combustion Option

Edited by:

Richard T. Sheahan, P.E.

Sponsored by:

Association of Physical Plant Administrators
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PREFACE

Government Institutes, Inc., is pleased to publish the following Proceedings of the 4th National Conference on "Evaluating the Fluidized Bed Combustion Option", held in June 1986 in Washington, D.C.

Since we organized the first Conference of this kind in October 1983, the costs of traditional gas and oil boiler fuels have been at high and low extremes. Despite these price uncertainties, we have seen a continuing, steady growth in the number of industrial, institutional and utility FBC projects coming on-line. As prices stabilize, it will be a true test of the maturity of the technology to see if boiler owners and operators continue to embrace the cost-benefits of fluid bed technology. Based on the information provided in this book, there is every reason to concur with a recent report from the Electric Power Research Institute that proclaimed that FBC is starting to live up to its promise as "the most significant innovation in coal combustion in over a century."

We are pleased that this FBC Conference—the major one of its kind designed for the potential end-user—continues to play a key role in the information transfer from those who have developed or are currently using FBC systems to those who are evaluating potential applications at their facilities. Contributors to this book include five FBC users; two project developers; and key suppliers of fuels, equipment and services to this burgeoning industry. The book also contains information supplied by 28 FBC system manufacturers, including several overseas vendors who are bringing their technologies to the United States.

We wish to thank the sponsors of the Conference—the Association of Physical Plant Administrators, the National Coal Association, and the National Wood Energy Association—for their programming advice and interest in serving their members with this information. Rick Sheahan, the Conference Program Chairman, deserves special thanks and recognition for his coordination of the program content and speaker selection, and his writing contributions to this document. We also thank all the authors who contributed their time and expertise to writing the following papers and sharing their insights and experiences with you, the reader.

Clearly commercial FBC technology now is fact, not fiction, and it is our desire that these factual proceedings may act as a catalyst for further applications of this exciting technology.

Martin Heavner
Vice President
Government Institutes, Inc.

EVALUATING THE

FLUIDIZED BED COMBUSTION OPTION

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BIOGRAPHICAL INFORMATION SHEET

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Rick Sheahan is President of Energy Partners, Inc., an energy and finance oriented firm in Washington, D.C. He is a registered professional engineer with more than 17 years experience in management of energy and financial related projects. In the last several years he has been involved in the technical and financial evaluations of FBC systems for the heating facilities at Princeton University, the University of Pennsylvania, Cornell University and three industries in the Midwest. His is author of four energy oriented books, two of which relate to Fluidized Bed Combustion. He has been the Program Chairman and organizer of the National "Evaluating the Fluidized Bed Combustion" Conference, held annually since 1983.

Mr. Sheahan earned his BS and MS in Engineering at Notre Dame and his MBA from George Washington University.

FUNDAMENTALS OF FBC UTILIZATION INCLUDING COGENERATION

By

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The purpose of this paper is to indicate a concise overview of the fundamental principles of Fluidizded Bed Combustion (FBC) and its ancillary functions, including cogeneration (i.e. simultaneous production of steam and electicity). The intention is not to be all-inclusive, but rather serve as a primer of FBC basics. More specific detail is given in other papers presented at this National FBC Option Conference.

A. GENERAL

FBC is not a new concept, but has had industrial applications dating back to the 1920's. In an FBC system, fuel is injected and burned in a hot turbulent bed composed of ash, sand and/or a sulfur sorbent. It is commercially available in very small (i.e. about 3,000 pph) to very large capacities (over 600,000 pph). Rapid flow of upward moving air suspends fuel and bed particles in an ebullient or fluidized manner during combustion.

FBC has several advantages over direct combustion:

Fuel is burned in intimate contact with sulfur sorbent (e.g. limestone or dolomite) which chemically reacts with sulfur in the fuel to form a solid and inert residue (i.e. calcium sulfate, which is gypsum) and discharges with the ash.

Combustion temperatures are low at about 1,700 degrees F. (compared to about 2,500 to 3,000 F. for direct combustion) which is below the ash fusion temperature of most solid fuels; thus, a dry, stable, powdery ash is formed.

The powdery ash and calcium sulfate mixture can easily be disposed of by landfill or has potential byproduct market value as a construction material supplement or chemical feedstock.

Low combustion temperature results in very low production of Nitrogen Dioxide in its flue gas air emissions.

FBC has significant multifuels flexibility.

B. MULTIFUEL FLEXIBILITY

More than any other type of combustion system, FBC systems are flexible in its ability to burn practically any combustible material. Material and fuels which have been successfully burned in FBC units include:

Coal of all types	Natural gas
Pelletized wood wastes	#2 & #6 oil
Pelletized paper wastes	Peat
Shredded rubber	Asphalt shingle wastes
Industrial waste oils	Petroleum coke
Anthracite culm	Oil shale
Wood chips	Fruit pits
Alcohol mash waste	Rice hulls
Paper mill sludge	Sewage sludge
Carpet wastes	Municipal refuse
Biomass wastes	Coal washing wastes
Vegtable composts	Sulfur-laden waste gases
And others	

Because of its abundant availabilty, coal will ultimately have the greatest application for FBC utilization

C. FUEL HANDLING AND STORAGE

Fuel handling and storage considerations for an FBC system are basically the same as any coal or solid fuel combustion system, and include:

Type of fuel to be used and its geographic availability.

Fuel supply reliability on a long term basis.

Access to transportation modes such as railroad, trucking and/or waterways.

Facility capabilities to receive, handle and store fuel. Storage may be either in closed silos or open ground storage. Fuel handling hoppers, conveyors, etc. are similar to any conventional system.

Major siting considerations include: land availabilty, area for storage and FBC system, local traffic impacts for fuel delivery and ash disposal, localized environmental impacts due to dust, noise, fuel storage rainfall runoff, aesthetics, etc.

D. BED DESIGN CONFIGURATION

There are several generic bed design configurations, which generally include:

Conventional or "bubbling" bed.
In-bed circulation.
Circulating bed.
Multistage.

1. Conventional or "bubbling" bed (Figure 1): Features include:

Horizontal air distributor plate and vertical walls.

Vertical uniform fluidizing air flow with little lateral mixing.

Elutriation of "fines" (i.e. carbon and flyash particles) in flue gas is high and generally requires recirculation of captured particles from mechanical collectors back to combustion area.

Generally requires double-screened fuels and sulfur sorbents to minimize input of "fines".

Fuel residency time is relatively short thus reducing efficiency of combustion and calcium-sulfur reaction.

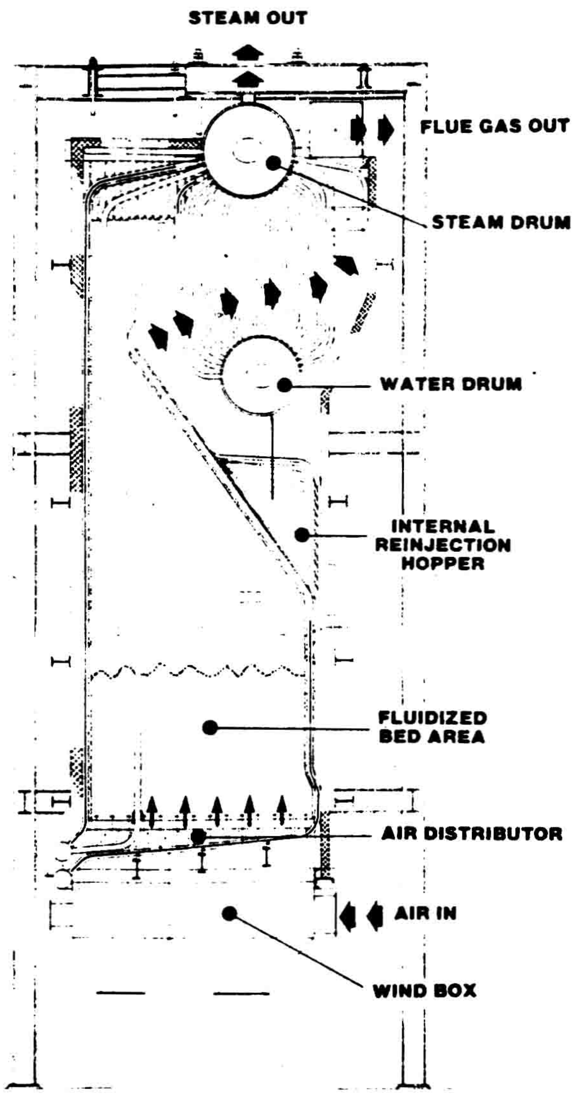
Physical dimensions are generally smaller than a circulating bed system of comparable capacity.

2. In-bed circulation (Figure 2): Features include:

Bed is configured to create circular or lateral forces in combustion area by various means, including:

Bending one chamber wall inward and over portion of bed.
Sloping air distributor plate.
Concave bed.
Tangential fuel feeding.

Lateral or circulating forces increases in-bed residency time, thus theoretically increasing combustion and sulfur sorbent reaction efficiency.



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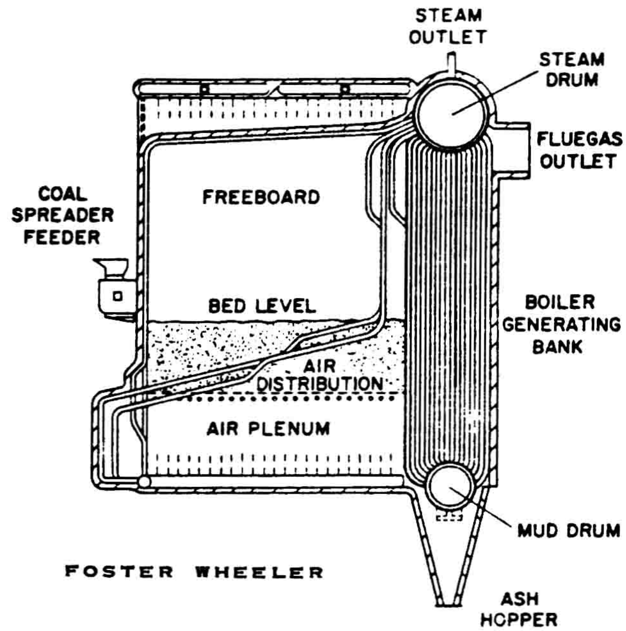
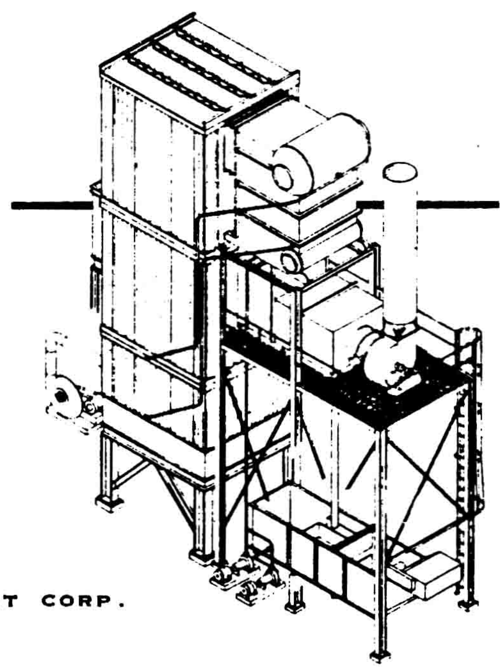
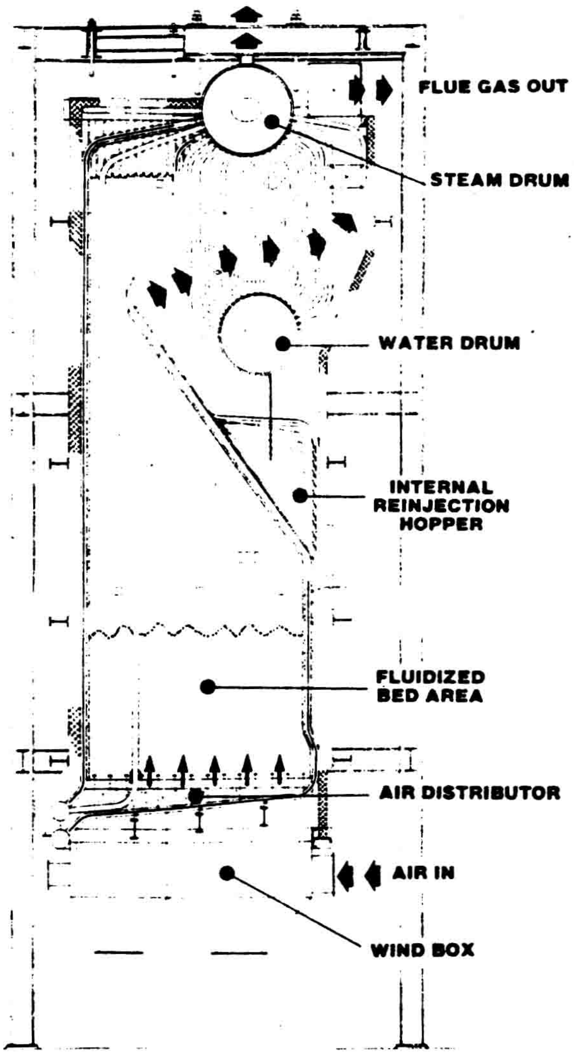


FOSTER WHEELER



DEDERT CORP.

FIGURE 1. CONVENTIONAL OR BUBBLING BED FBC SYSTEMS



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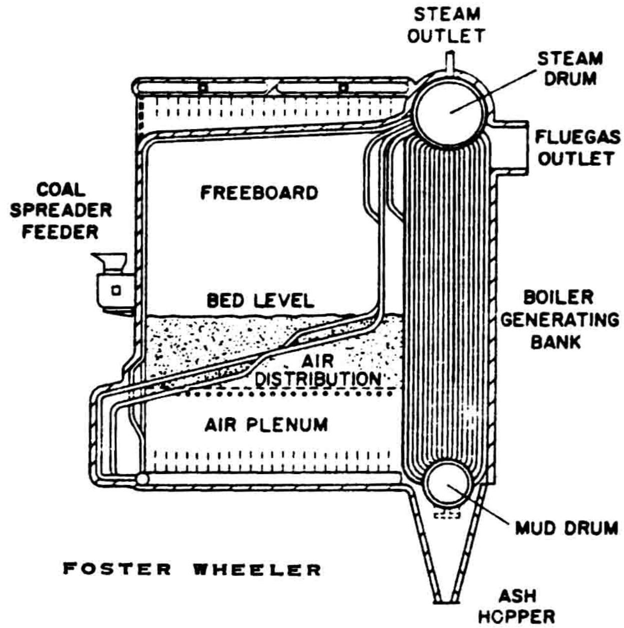

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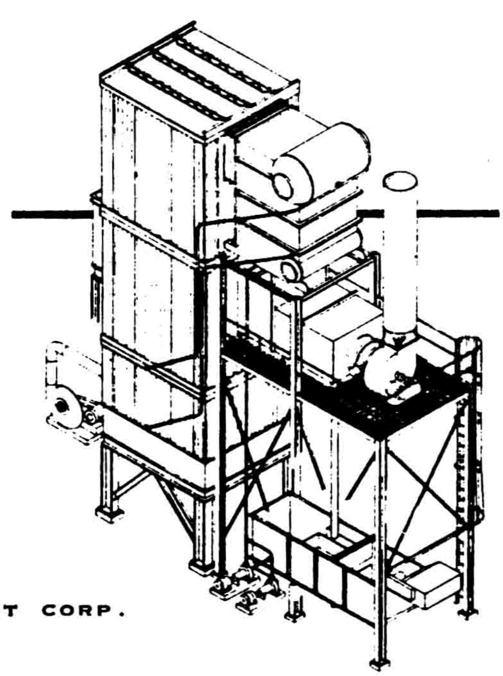

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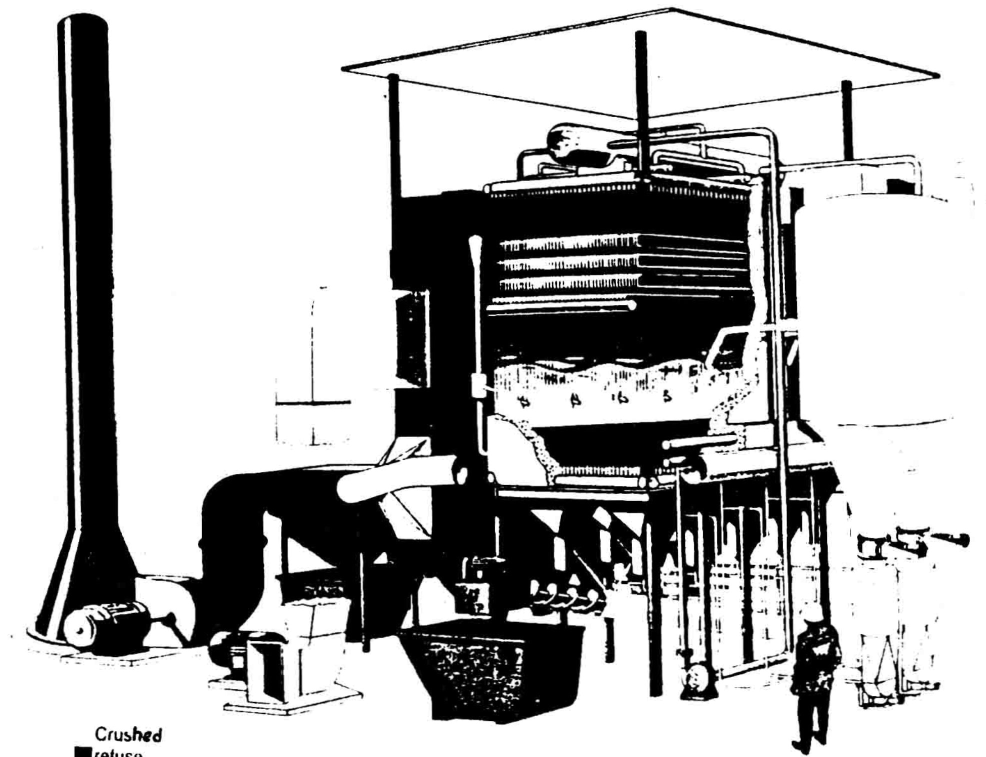

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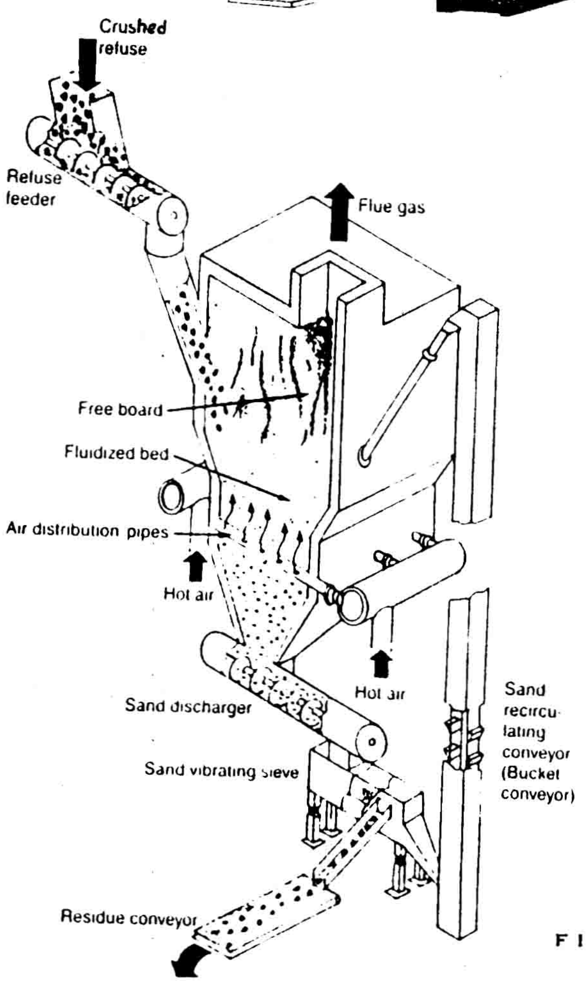
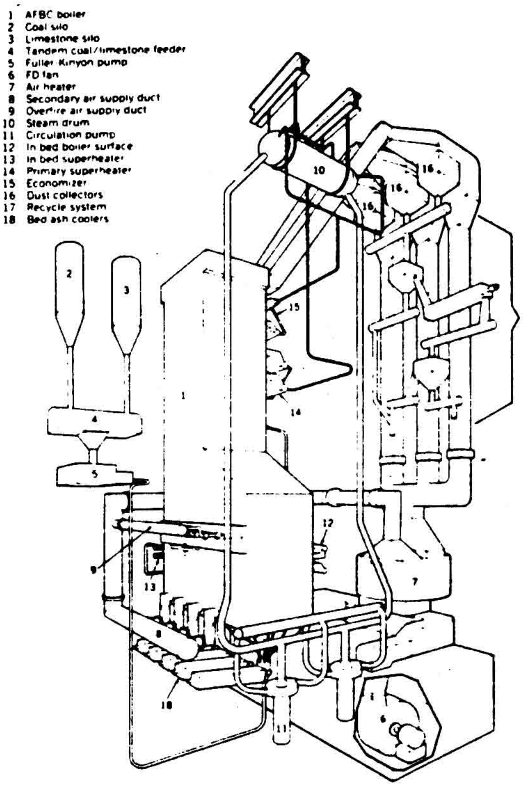


DREVER CO.

FIGURE 1. (CONT) CONVENTIONAL BED



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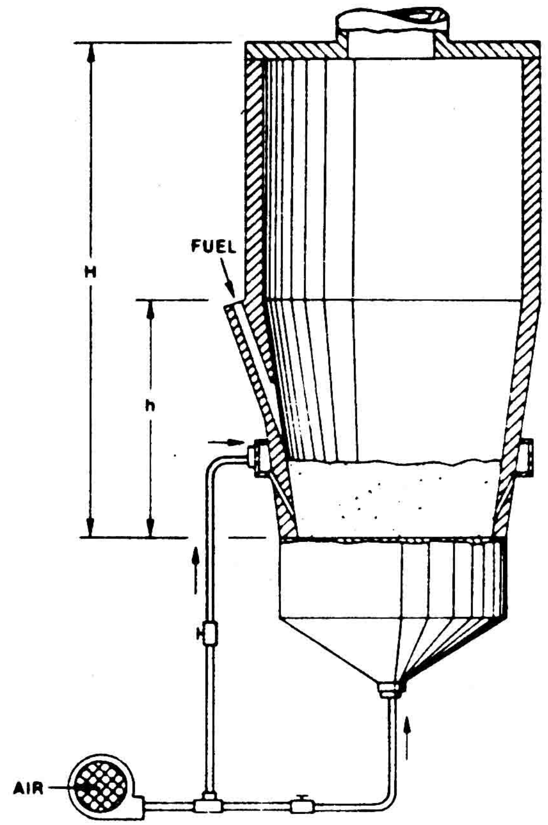

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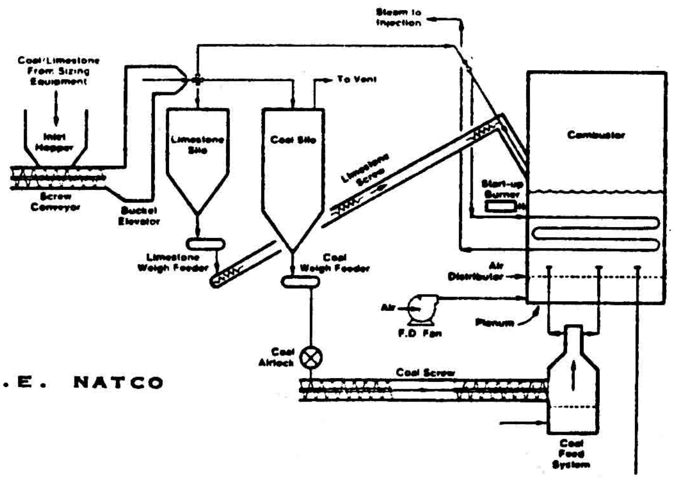

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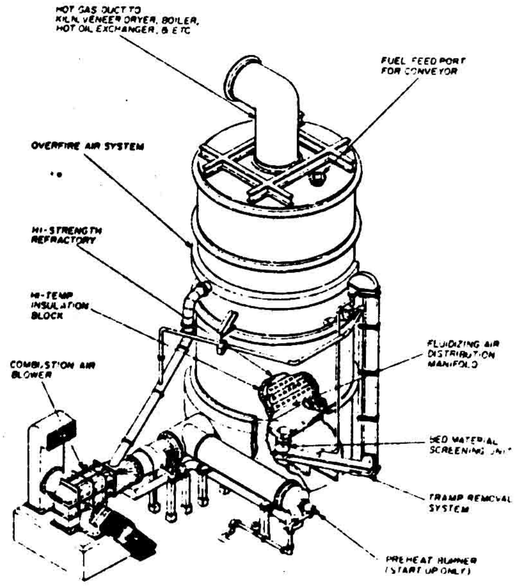
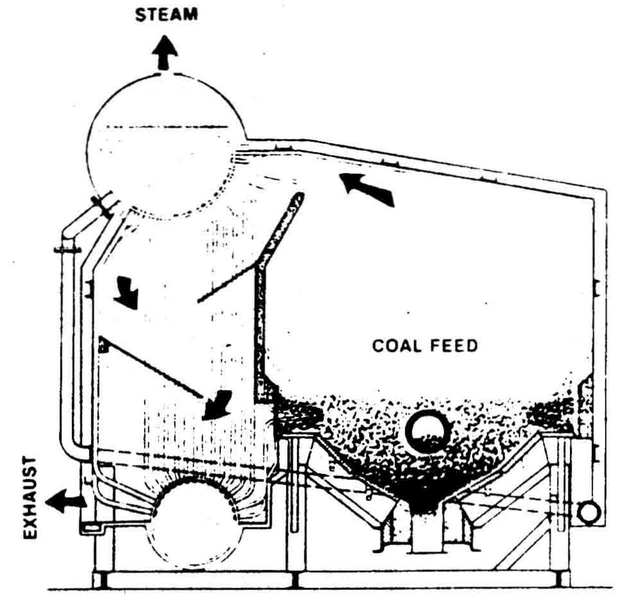


ENERGY PRODUCTS OF IDAHO

FIGURE 1. (CONT) CONVENTIONAL OR BUBBLING BED FBC SYSTEMS



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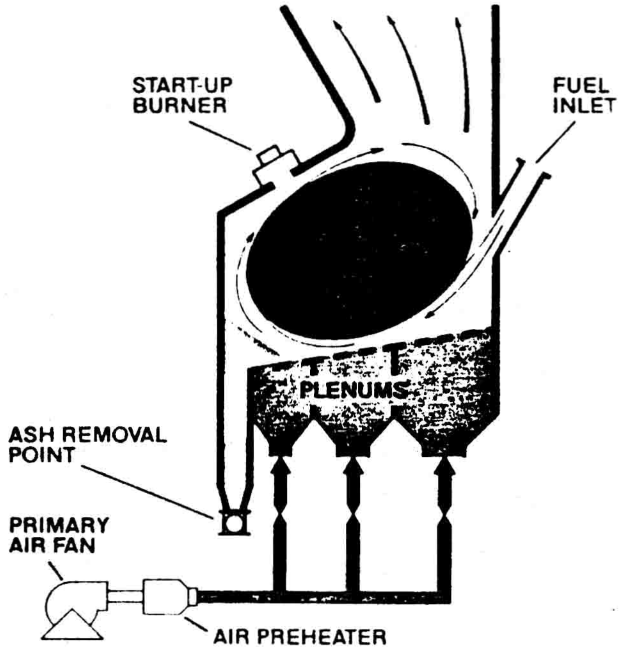

INTERNATIONAL BOILER WORKS

FIGURE 2. IN-BED CIRCULATING FBC SYSTEMS

3. Circulating bed (Figure 3): Features include:

Portion of bed is configured as an upcomer to promote and maintain solids elutriation. Fines are drawn up and through upcomer to enhance residency times and thus greater combustion and sulfur sorbent efficiencies.

Fines drop through downflow channel to impart horizontal velocities across combustion bed, thus creating lateral mixing forces.

Less concern for "fines" content of fuels and sulfur sorbents.

Requires less sulfur sorbent than "bubbling beds" to achieve comparable sulfur removal.

Physical dimensions of system are generally larger than a "bubbling bed" of comparable capacity.

4. Multistage bed (Figure 4): Features include:

System has two separate beds.

Bottom bed is composed of inert material (i.e. sand) and fuel where combustion occurs.

Top bed is composed of finely ground sulfur sorbent where desulfurization of flue gases (from bottom bed) occurs.

Combustion temperature is higher in bottom bed for maximum combustion efficiency; whereas, temperature in top bed is lower for maximum sulfur removal.

Physical dimensions of system are generally smaller than either a "bubbling bed" or a circulating bed system of comparable capacity.

E. FUEL FEED SYSTEMS

Basically there are two general methods of feeding fuels to an FBC system: overfeed and underfeed.

Overfeed by means of gravity or stoker system. Fuel is projected over combustion area of bed.

Underfeed by means of pneumatic ejectors. Has increased maintenance, is more sophisticated, requires additional pulverization costs; however, can lead to higher combustion efficiencies since material must "work" its way up and through bed which increases residency time and therefore, theoretically, is more efficient.