COAL CONVERSION CONSIDERATIONS FOR INDUSTRIAL BOILERS

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ABSTRACT

Combustion of coal as an alternate to petroleum fuel and natural gas in industrial boilers is receiving much attention—thanks to the present "energy-politics" of the Middle East and the dwindling domestic resources of petroleum fuels.

This discussion provides the general data base which facilitates proper evaluation of conversion considerations of existing oil and gas firing industrial units to bituminous coal firing.

The discussion also presents the range of related fuel burning equipment as marketed by Riley Stoker Corporation and also environmental considerations of such conversion studies.

THE ENERGY DILEMMA

The industrial society, which has been nurtured over the past three decades by the abundant provisions of the petroleum fuels, today is faced with a dilemma to seek an alternate source for its very sustenance. These events, which have led the industrial society to its current dilemma, have been a "hot favorite" for a number of studies and seminars. The results of all these studies have been strikingly similar. In short, it is predicted that between 1985 and 1995, the supply of petroleum fuels will fail to meet the demand, despite an exponential rise in prices. Obviously, the search for alternative energy sources has thus become long overdue.

Various statistics in energy consumption patterns have all been in agreement that the ratio of energy used in the industrial sector to the total energy consumption for the United States is in the range of 1: 2.5 to 2.9. Table 1 and Figure 1 (following) illustrate the consumption pattern in the United States. It can be observed that the net petroleum consumption in the industrial sector is approximately 1/3 of the total imports in 1975. The projections for future imports are based on the dwindling domestic petroleum output and the ever increasing gap between demand and recovery from domestic resources.

ENERGY UTILIZATION PATTERN FOR UNITED STATES—1950-2000

YEAR OF CONSUMPTION	TOTAL ANNUAL CONSUMPTION	CONSUMPTION PATTERN IN INDUSTRIAL SECTOR				TOTAL ANNUAL IMPORTS IN QUADS
		TOTAL UNITS IN QUADS	PETROLEUM CONTRIBUTION (PERCENT)	NATURAL GAS CONTRIBUTION (PERCENT)	COAL CONTRIBUTION (PERCENT)	
1950	35.2	11.9	18.5	31.1	50.4	
1955	39.7	13.9	26.6	30.2	43.2	
1960	45.6	14.4	23.6	45.1	31.3	3.3
1965	53.3	17.1	24.0	40.9	35.1	5.6
1970	58.1	19.8	25.3	49.5	25.2	6.7
1975	70.5	20.3	25.6	47.3	27.1	15.5
1979	81.9	31.6*	23.4*	45.4*	31.2*	16.5
2000	114*	46.7*	11.0**	20.5**	68.5**	15.5**

* Approximate estimates.
** Proposed targets based on current technology for coal production.

TABLE 1

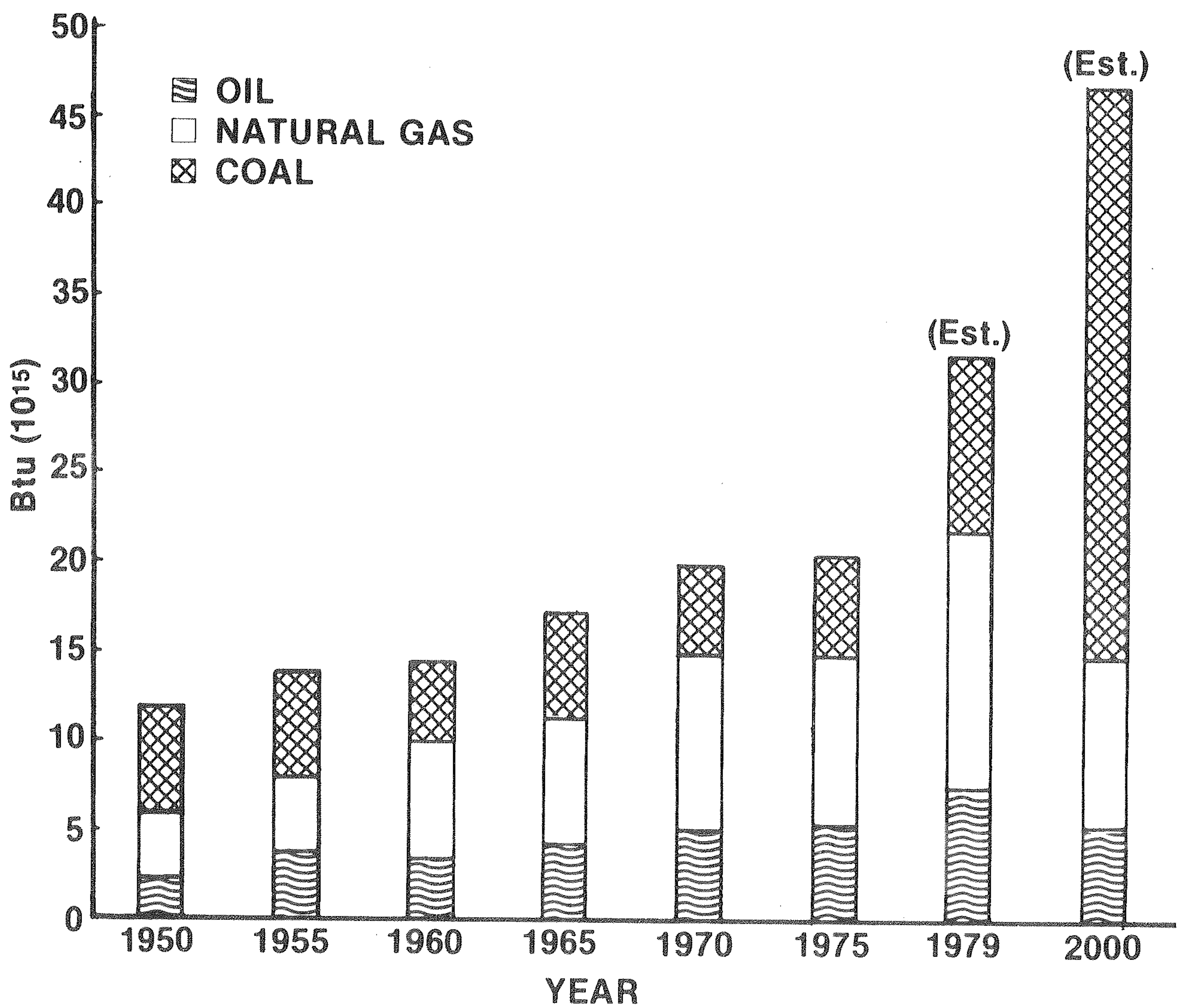

Figure 1 Annual Energy Consumption Pattern

On the other hand, since 1965, consumption of coal in the industrial sector has steadily declined, thus industry is relying more heavily on petroleum fuel and natural gas.

Further, the American Petroleum Institute has reported that in 1979 the cumulative deficit in domestic petroleum reserves was increased by another 800 million barrels.

These results, in the wake of the current trends in OPEC policy, and added to the political pressures in the Middle East countries, necessitate a search for alternatives to petroleum fuels. The information presented in this discussion offers one alternative to the problem.

In effect, it is becoming more and more evident that the economic principle of elastic prices cannot be held valid for a wasting, non-renewable energy resource. Hence, sooner or later, this country has to reduce its imports and manage from within the domestic availabilities.

COAL AS AN ALTERNATE

Amidst the ever increasing gloominess of the energy picture, the industrial society has a ray of hope in domestically available coal. It has been estimated that the domestic coal resources are approximately 1/3 of the world's known resources. In a 1975 bulletin, "Mineral Facts and Problems," the U.S. Bureau of Mines estimated a total of 437 billion tons (ER) of coal in deposits. The current rate of consumption is approximately 700 million tons a year. Thus, even with a threefold increase in the rate of coal production, coal is available in increasing quantity to mitigate our current reliance on imported fuel. Therefore it is safe to conclude that regardless of the present environmental and sociological constraints on its use, coal is the only abundant domestic energy resource capable of substantial expansion to keep our energy supply growing.

A comparison of potential and economically available resources to future rates of production is illustrated in Table 2.

ESTIMATED COAL RESOURCES AND FUTURE U.S. PRODUCTION TARGETS

WORLD COAL RESOURCE IN BILLION TONS		COMPARATIVE DOMESTIC RESOURCES IN BILLION TONS				DOMESTIC ANNUAL PRODUCTION RATES IN MILLION TONS			
				Percent Distribution					
Gross Geological	Technically Recoverable	Gross Geological	Technically & Economically Recoverable	Brown Coal	Hard Coal	1978	1985	1999	2000
10 124	1 148	2 686	437	36	64	700	995	1 250	1 700

TABLE 2

Thus, in this era of uncertain petroleum supplies and steeply rising fuel costs, conversion to an alternate energy system, particularly coal, is not only a corporate virtue, but an object of national concern. Biomass, oil shale, and synthetic fuels may suggest an idealistic energy system as an alternative to petroleum fuels; however, with the currently commercialized technologies, the utilization of such fuels seems to be a long way off.

INDUSTRIAL BOILERS

Steam generation for process heat and cogeneration consumes approximately 40% of the total fuel consumption in the manufacturing sector. Thus the potential towards mitigation of the current energy dilemma by conversion of petroleum based steam generation systems to coal firing is high.

It is generally understood that the industrial boiler sizes vary between 10,000 pounds per hour to 500,000 pounds per hour of actual steam generation capability. Table 3 lists an inventory of industrial boilers compiled by KVB, Inc. in 1975.

SUMMARY OF INDUSTRIAL BOILER SIZE AND TYPE INVENTORY

		1967 BOILER POPULATION		SALES 1967-1974		RETIRED 1967-1974		1975 BOILER POPULATION	
CAPACITY (10^6 Btu/hr)	FURNACE DESIGN	NO. OF UNITS	TOTAL CAPACITY 10^9 Btu/hr	NO. OF UNITS	TOTAL CAPACITY 10^9 Btu/hr	NO. OF UNITS	TOTAL CAPACITY 10^9 Btu/hr	NO. OF UNITS	TOTAL CAPACITY 10^9 Btu/hr
10-16	Watertube	7,300	91	375	5.2	176	2.4	7,499	93.8
16-100	Watertube	27,060	833	4,934	236.3	2,319	109.0	29,675	960.3
100-250	Watertube	4,015	658	1,157	180.3	845	131.6	4,327	706.7
250-500	Watertube	942	259	168	61.6	56	20.0	1,054	300.6
10-16	Firetube	9,970	126	6,615	85.1	1,190	15.3	15,215	195.8
16-30	Firetube	3,160	66	2,138	44.7	385	8.0	4,913	102.7
	Totals	52,267	2,033	15,387	613.2	4,971	286.8	62,683	2,359.9

Source: KVB, Inc., *Industrial Boiler User's Manual,* p. 204.

TABLE 3

Of the 62,683 steam generating units operating as of 1975, many were installed originally as coal-fired units, but between 1960 and 1975 were converted to oil firing. A large number of units installed from 1955 to date have been designed specifically for either oil or gas firing. Among these boilers, the number of potential conversion candidates is uncertain. The variables governing the feasibility of conversions are not limited to investment decisions alone. As a precondition to issuance of a prohibition order by D.O.E. for discontinuance of firing either natural gas or oil, it is necessary that D.O.E. be satisfied that coal firing is practicable and consistent with the purposes of the Energy Supply and Environmental Co-ordination Act. This includes suitability of boiler design, facilities for coal transportation, commitment of supplies, and emission control feasibility.

DESIGN CONSIDERATIONS

Fuel Influences—Combustion of coal in boiler furnaces requires special measures to assure a continuing supply of oxygen in contact with carbon particles as long as they remain unburned. The process of intimate mixing of air with coal particles is achieved better in a turbulent furnace which helps to remove the combustion products as they form at the surface of the fuel particles. Thus, higher furnace turbulence results in quicker and more complete combustion.

The general application for coal firing in industrial boilers varies with the type and grade of coal. Since the turn of the century, Riley Stoker Corporation has been committed to the development of coal firing equipments and relative furnace designs to meet the varied demands. However, for conversion of existing industrial oil- and gas-fired boilers to coal firing, only bituminous coal is considered within the scope of this paper. Different grades and types of coal can be applied to each individual requirement. Riley's Plant Improvement Division has the charter for fuel conversions, from feasibility studies to design and construction work.

Performance Constraints—Unlike the design of a new boiler, conversion studies must deal with an established design. This imposes certain restrictions on the mode and type of firing and also on acceptability of certain grades of coal. The following check points are primary considerations in such retrofit applications.

1) *Furnace Design*

a) In order to prevent excessive slag accumulation on furnace walls and on convection surfaces at furnace exit, heat release rate per unit EPRS (Effective Projected Radiant Surface) must be restricted. The relationship between furnace exit gas temperature and heat release rate is illustrated in Figure 2, depending on the slagging index of the coal.

b) Since coal requires more time for complete combustion than oil or gas, volumetric heat release rate in the furnace has a direct bearing on efficiency and particulate emissions. The recommended volumetric heat release rate for various modes of coal firing, based on bituminous coal, is tabulated in Table 4.

2) *Convective Surface Design*

Fouling characteristics of coal ash dictate acceptable gas velocities in the superheater and boiler bank convective passes. This factor determines tube spacing criteria. The recommended practice by Riley Stoker Corporation for tube spacing in convective passes is illustrated in Figure 3.

HEAT RELEASE RELATIONSHIP WITH MODE OF FIRING IN INDUSTRIAL BOILERS
Fuel = Bituminous Coal

	FURNACE HEAT RELEASE RATE				
MODE OF FIRING	VOLUMETRIC BTU/Hr Cu Ft	PROJECTED SURFACE BTU/Hr Ft²	ANTICIPATED FURNACE EXIT GAS TEMP. F	FURNACE FLOOR CONSTRUCTION	MAXIMUM GRATE HEAT RELEASE RATE BTU/Hr Ft²
Stoker	18,000 to 35,000	60,000 to 75,000	Approx. 1,750 F	Open floor with refractory arches and front and rear water wall headers.	850,000
Pulverized Coal	12,000 to 21,000	60,000 to 75,000	Approx. 1,900 F	Hopper bottom or slag tap—Either partially or fully water-cooled	N/A
Producer Gas	16,000 to 31,000	60,000 to 80,000	Approx. 1,900 F	Fully water-cooled membrane type is acceptable.	N/A
Atmospheric Fluidized Bed Combustion (AFBC)	Governed by main bed plan area heat release		Approx. 1,600 F	Bed cooling necessary—Either water or steam cooling.	700,000 Bed area heat release

TABLE 4

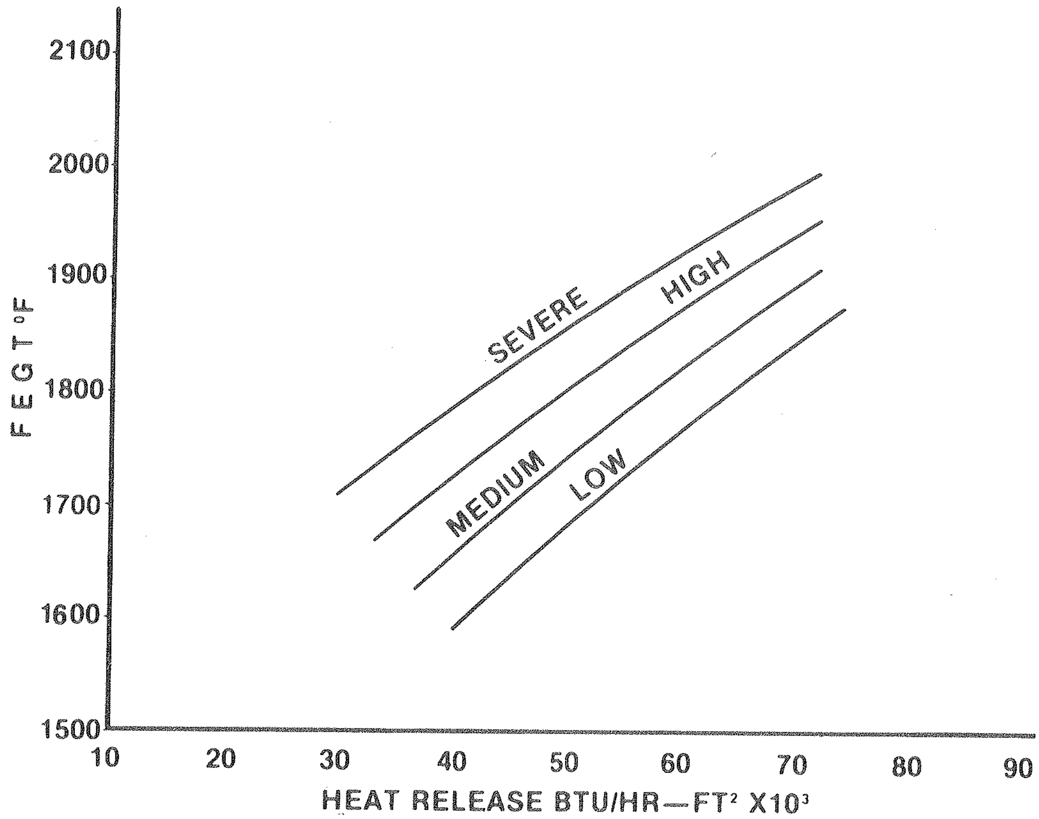

Figure 2 Relationship Between Slagging Index and Acceptable Furnace EPRS Heat Release Rate

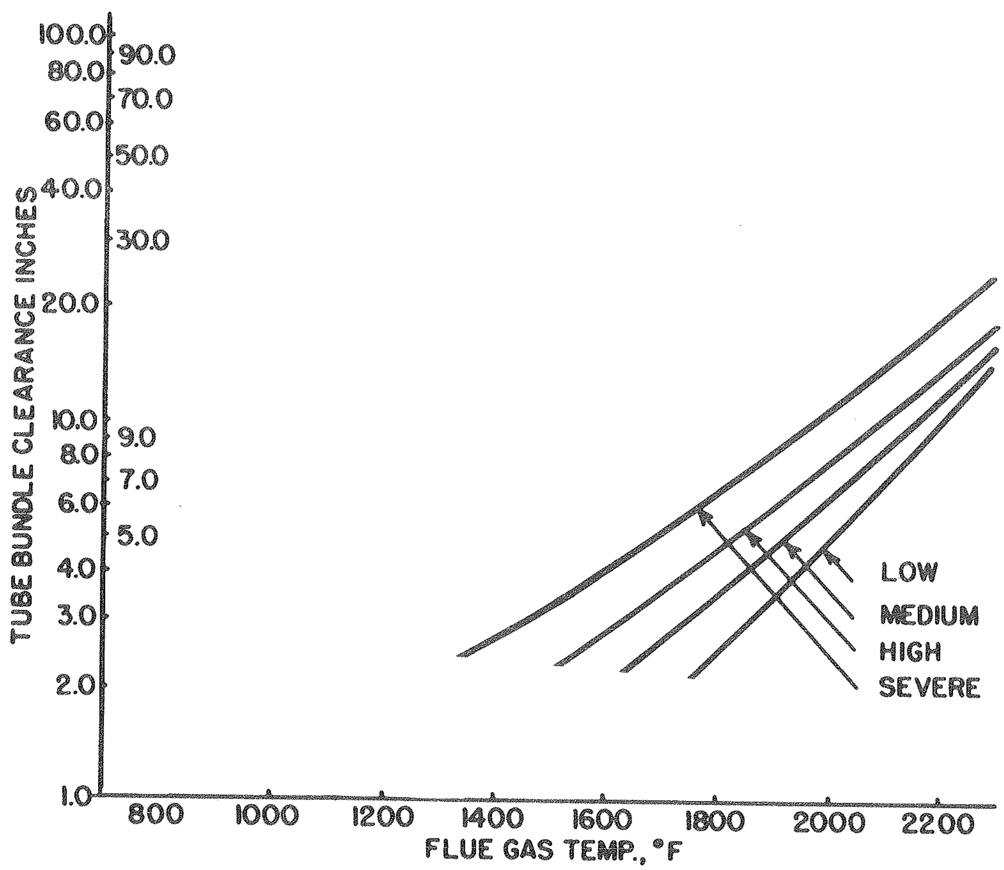

Figure 3 Convection Bank Design Criteria for Fouling Ash

3) *Waste Heat Recovery Equipment*

Depending on the chemistry of the coal and the boiler exit gas temperature, the size and constructional design of economizer and air heaters are established. Variations in performance of these equipments need review by the manufacturers. Due to considerations of "fin pitch" and tube spacing, and their relative effects on dust concentrations, corrosion and ash fouling must be scrutinized with utmost care for trouble-free performance of the boiler.

4) *Fans*

Mode of firing, fuel analysis and operable efficiency are the various factors which together determine capacity and static pressure requirements of forced draft, overfire air and induced draft fans. An overfire air fan is a necessity with stoker firing systems. Table 5 illustrates the combustion air requirements for different modes of firing.

5) *Soot Blowing Equipment*

Depending on coal ash fouling and slagging indices, boiler geometry and available blowing media generally determine the type and quantity requirement of soot blowing equipment. It is customary to consider rotary wall deslaggers for the furnace walls and either long or short retractable soot blowers for boiler bank, superheater and screen tubes. These tube cleaning devices have a direct bearing on boiler availability and operating efficiency of the unit. Soot blowers for economizers also are necessary.

CONSIDERATIONS FOR COAL COMBUSTION

Table 6 furnishes proximate analysis for the commonly available bituminous coals in this country. Considerations for retrofit of coal firing systems to industrial boilers are better applied for coals within the specified ranges.

It is also understood that the commercial size of coal available for such stoker-fired industrial boiler retrofit applications will not be retained on 1 1/4 inch round hole screens. For pulverized firing applications, coal should pass through 3/4 inch round hole screens.

Based on the variables detailed above, effective combustion of coal varies with type and mode of firing and furnace geometry. Among the variables, the volatile matter burns more thoroughly and therefore provides maximum yield of available energy.

RECOMMENDED EXCESS AIR REQUIREMENT WITH VARIOUS MODES OF FIRING IN INDUSTRIAL BOILERS

Fuel = Bituminous Coal

MODE OF FIRING	RECOMMENDED EXCESS AIR MCR CONDITION (PERCENT)	THEORETICAL COMBUSTION AIR (DRY) PER 10,000 BTU	TOTAL COMBUSTION AIR (WET) PER 10,000 BTU INPUT
Stoker	30	7.5 lbs	9.88 lbs
Pulverized Coal	20	7.5 lbs	9.12 lbs
Producer Gas	10	5.4 lbs	6.02 lbs
Atmospheric Fluidized Bed Combustion (AFBC)	25	7.5 lbs	9.50 lbs

TABLE 5

PROXIMATE ANALYSIS FOR DIFFERENT KINDS OF BITUMINOUS COALS

CLASS	GROUP	CONSTITUENT PERCENTAGE BY WEIGHT					AVERAGE HIGH HEATING VALUE BTU/#
		FIXED CARBON (DFM BASIS)	VOLATILE MATTER (DFM BASIS)	MOISTURE (NATURAL INHERENT CONTENT ONLY)	ASH	SULPHUR	
Bituminous Coals	Low Volatile	68-78	16 to 20	1 to 1.5	5 to 8	0.7 to 1.5	13,700 to 14,700
	Medium Volatile	57-68	20 to 30	1.5 to 2.5	8 to 10	1.5 to 2.5	13,300 to 13,800
	High Volatile	40-58	30 to 40	2.5 to 6.0	9 to 12	2.0 to 4.0	11,300 to 13,300

TABLE 6

In the right combination of boiler design, burning equipment and proper boiler operation, furnace design effectively extracts maximum heat value from the fuel within the furnace area—where combustion should take place. Incomplete combustion may cause carryover of cumbustibles into other areas of the boiler resulting in excessive metal temperatures, fouling and erosion.

Even with the proper combination of all variables governing the design, non-volatile and unburnt constituents of coal tend to accumulate on the fire side of the boiler tubes. Such accumulations are classified as either slagging or fouling tendencies.

MODES OF COAL FIRING

Within the limited approach for retrofit application, the modes of firing normally recommended are:

1) Spreader Stoker Firing

2) Pulverized Coal Firing

3) Producer Gas Firing

4) Fluidized Bed Coal Firing

Spreader Stoker Firing

Spreader stokers of the traveling grate type are probably the most popular stoker applications with industrial boilers because of their relative simplicity, low maintenance and ability to respond to load variations. Spreader stokers are known to operate effectively with coals having a wide range of moisture, volatile and ash constituents. These types of stokers are readily adaptable for bark firing in combination with coal.

Figures 4 and 5 illustrate typical applications of spreader stokers to either partially or fully water-cooled front, rear and side walls. Boiler capacity has been used as the index for determining the type of wall construction with such applications. Riley Stoker has suitable traveling grate designs for application with boilers rated 20,000 to 250,000 PPH steam generating capability. Twin grate applications are possible for boilers over 250,000 PPH.

Retrofit capability is highly recommended for boilers with air-cooled refractory floor construction. Space availability for ash pit, plenum chamber and cinder collection are the governing factors determining retrofit possibility. Available furnace volume and effective projected radiant surface of the furnace envelope determine the maximum applicable heat release in the furnace, and thus the maximum steam generation capability. Derating of an existing unit may become necessary under such retrofit applications.

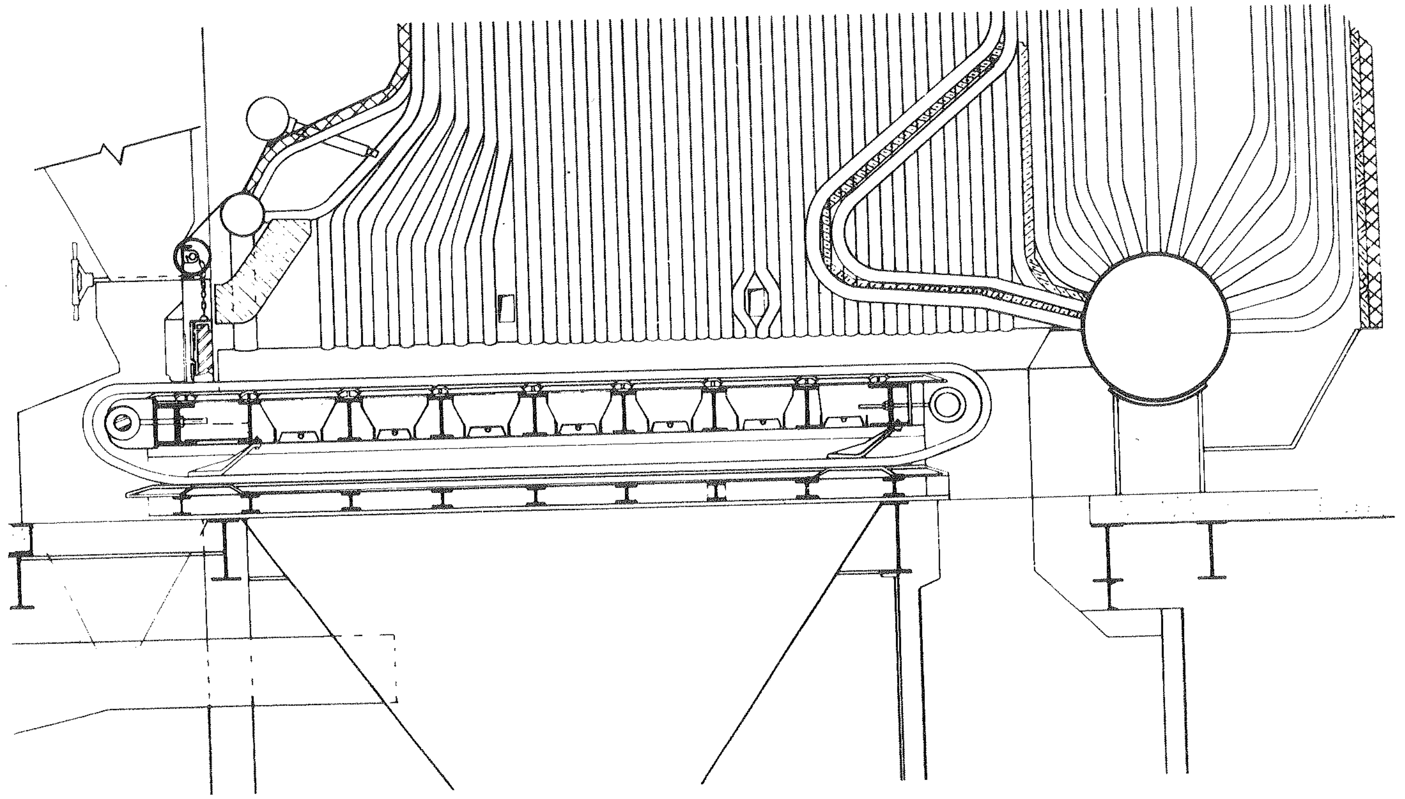

Figure 4 Riley Traveling Grate Stoker

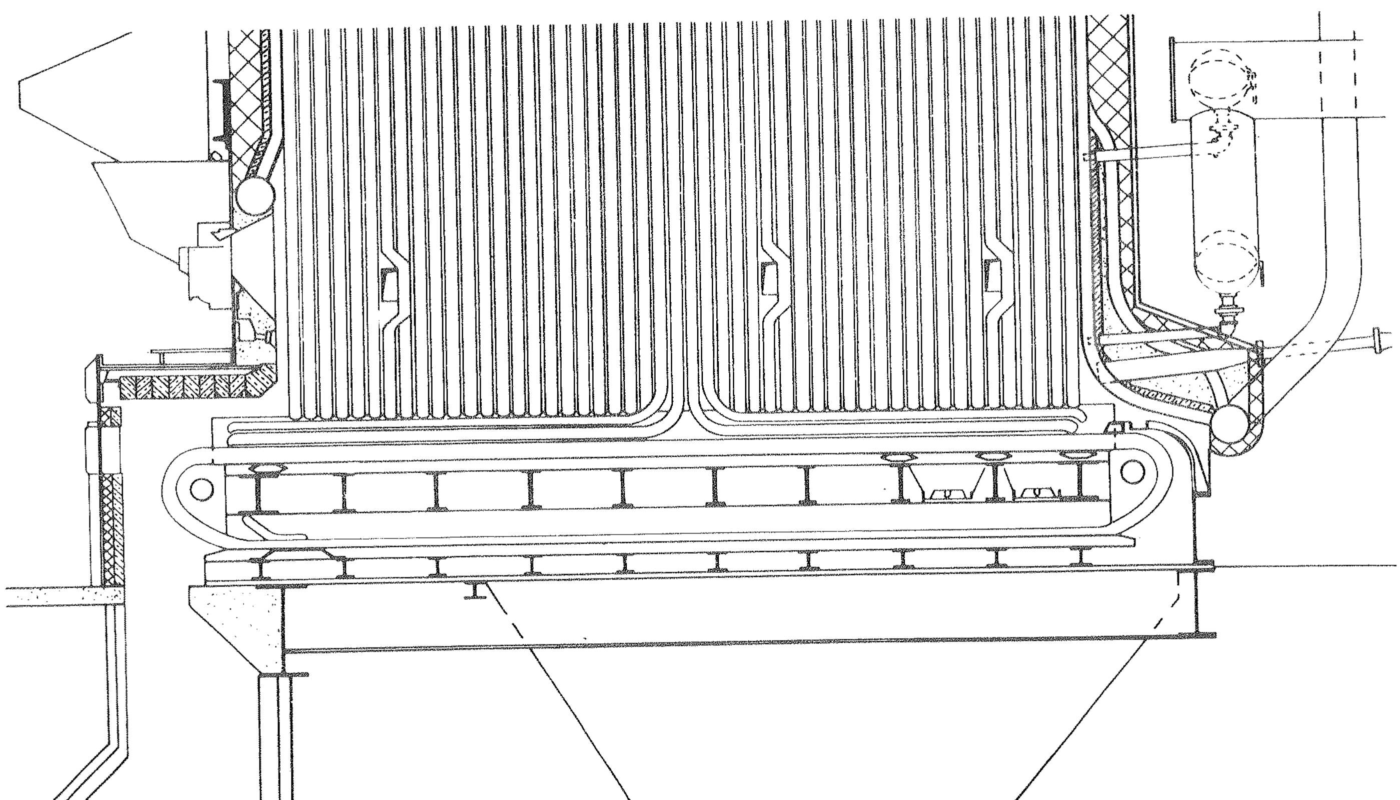

Figure 5 Riley Spreader Stoker

The potential for achieving rated continuous output is dependent upon the feasibility of extending the furnace geometry by either excavation or by elevating the boiler. Top support units with allowances for reinforcements are ideal candidates for such retrofits.

Other types of spreader stokers, such as water-cooled type, can be considered depending upon rate of firing, type of fuel, requirement of auxiliary fuels for simultaneous firing and possible modification to furnace wall construction.

Spreader stokers are associated with high particulate emissions. Also, when subjected to high grate heat release rates, carry-over of unburnt carbon increases. This necessitates effective cinder reinjection systems to maintain optimum efficiency. In addition to cinder reinjection, suitable dust collecting devices also are necessary to maintain low stack emissions.

With spreader stokers, a substantial amount of combustion air is introduced into the furnace above the grate as overfire air. These high pressure jet streams of overfire air induce a swirling turbulent motion above the grate area, thus arresting escape of vaporized volatile matter and simultaneously assuring rapid combustion. Lack of overfire air results in increased smoke density at the stack exit and higher carbon loss.

Pulverized Coal Firing

Stoker firing is extremely sensitive to fuel size, segregation and moisture. These fuel factors coupled with grate operating factors such as bed depth, grate speed, plenum chamber air pressures and overfire air, and stoker variables such as rate of feed and fuel trajectory, cause stoker operation to be subject to high variability. In contrast, pulverized coal firing has been developed to provide for comparatively higher reliability. In addition pulverized coal firing helps achieve minimum carbon loss, lower excess air requirement and hence a higher operating efficiency. Once adjusted to accommodate a given coal, the air and fuel mechanisms of the burner operate in harmony for a controlled excess air ratio with a homogeneous fuel mixture.

Figure 6 illustrates a typical arrangement of a pulverized coal firing unit. Pulverized coal firing requires the installation of high efficiency flyash collecting systems due to a high concentration of particles under 30 microns. In the case of the spreader stoker, concentration of particulates under 30 microns is less than half of such concentration associated with pulverized coal firing. As an example, for a 200,000 PPH stoker-fired industrial boiler, estimated particulate loading in the stack indicates approximately 30% to be under 30 microns; for an equivalent capacity pulverized coal fired boiler, it will be about 65%. Though furnace design, fuel and baffles would marginally influence the dust loading, the variation in concentration is largely associated with this type of firing.

Retrofit capability is very well suited for top supported construction with water-cooled floors. Modification to the furnace is in furnishing a hopper bottom, wherein one or two bottom headers would be provided to terminate both the front and rear wall tubes. New header feeders would also be required. However, with due consideration to tube spacing, rate of firing would be limited on furnace capability. Both the furnace volume and EPRS can be augmented by excavating the floor underneath. In any event, space for removal of ash is a necessity.

Producer Gas Firing

Retrofitting the more conventional modes of firing to boilers initially designed for only oil or gas firing is dictated by resistance to gas mass flow through the convection bank and superheater area. Boilers with close tube spacings are ideal for application of the Riley coal gasifier as shown in Figure 7.

These gasifiers are commercially proven and are offered with guarantees to meet rated performance under strict compliance with OSHA and EPA regulations. The Riley gasifier is of the thin bed, partial oxidation furnace type, and yields low BTU gas utilizing a wide variety of coals, including lignite. The

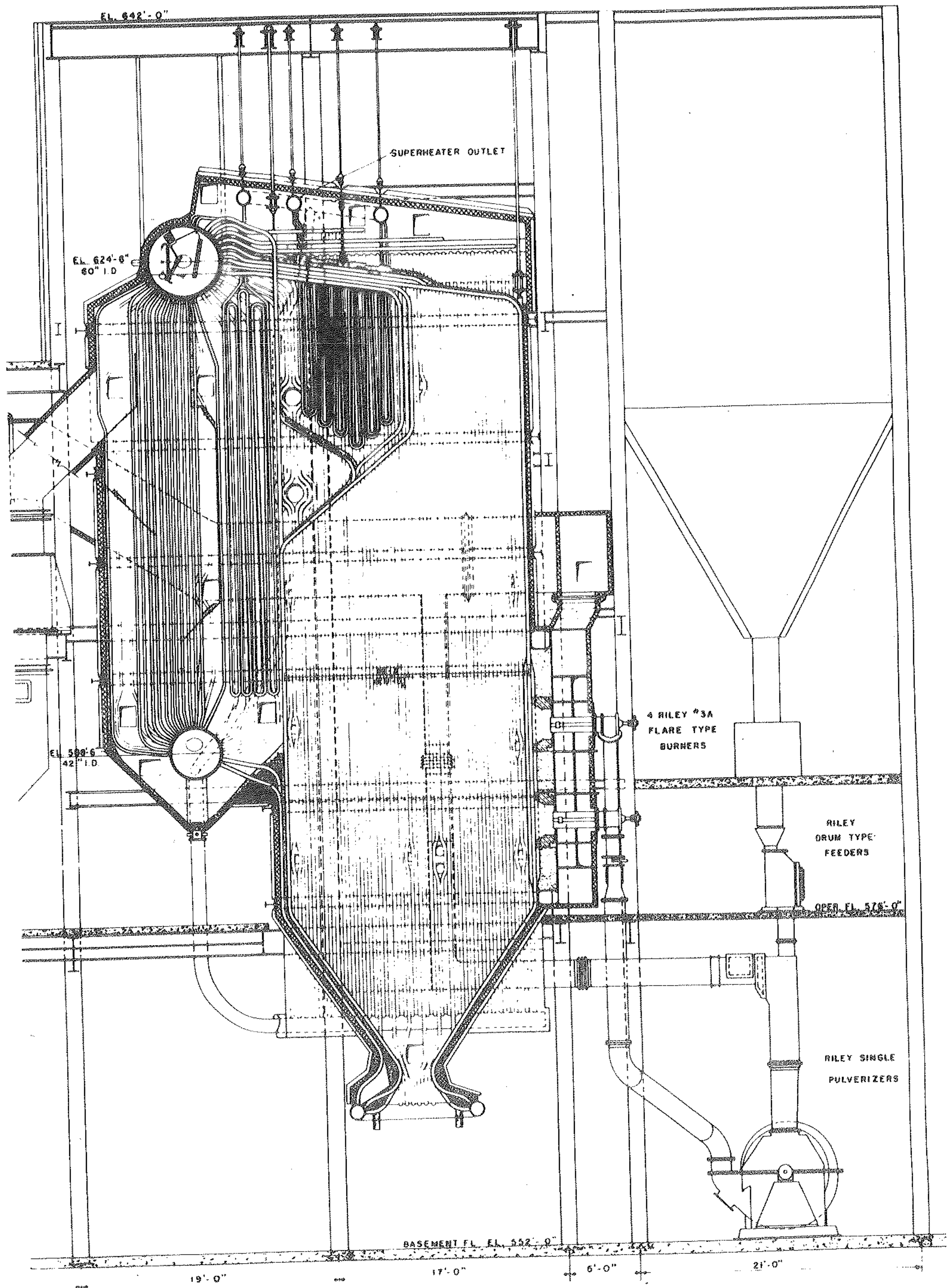

Figure 6 Typical Pulverized Coal Fired Unit

present design operates under a slight pressure with a water-cooled rotating drum, a water seal, a water-cooled agitator and an automatic ash removal system. Units can be supplied with a sulphur and tar removal system.

Since the Riley gasifier yields comparatively clean gas, the requirement for soot blowing equipment is very minimal. A closely-spaced finned tube airheater or economizer may be adaptable to such changes in fuel. However, gas volume handled will be very high in comparison to #6 oil or natural gas-fired units. With optimum heat recovery possible, overall thermal efficiency of boiler units with gasifiers will be comparable to overall thermal efficiency with #6 oil as designed.

The increased gas mass flow and a possible increase in gas temperature at furnace exit may indicate susceptibility of superheater tubes and increased steam temperature. Suitable metallurgical revisions and steam temperature control systems may become necessary.

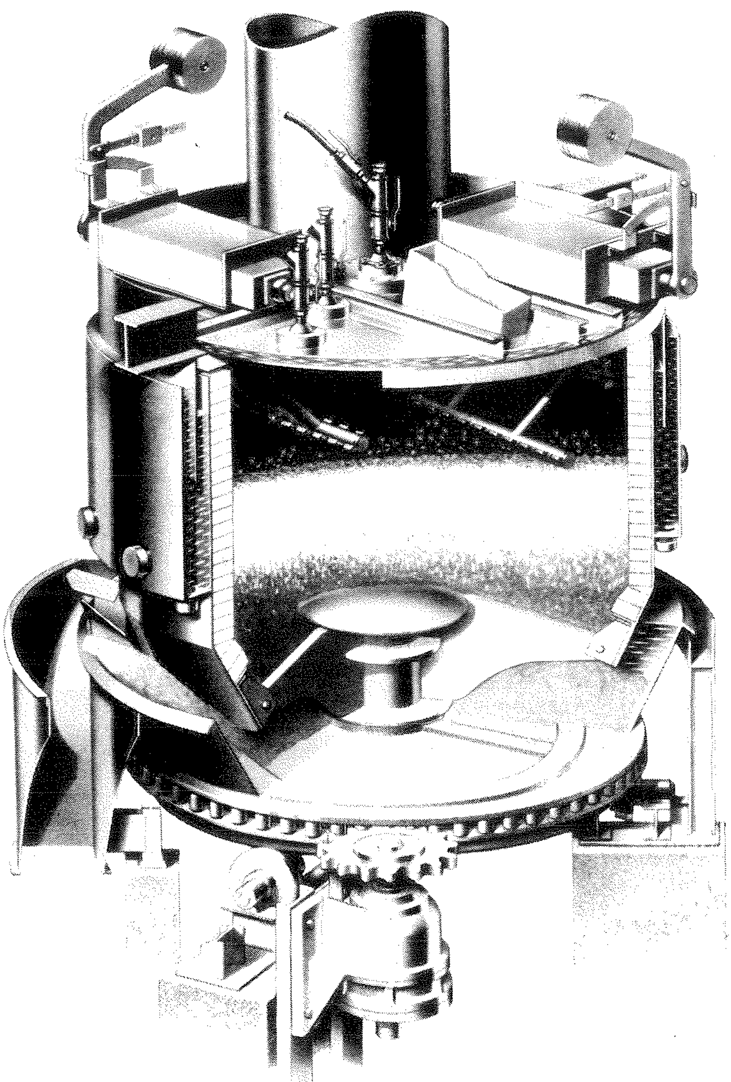

Figure 7 Riley Gasifier

Fluidized Bed Coal Firing

The various modes of coal firing described to this point, present problems to the users because of space requirements, environmental restrictions and complexity of operation. Riley Stoker Corporation, in collaboration with Babcock Contractors, Inc. (BCI), is working on the design and construction of atmospheric fluidized bed combustion of coal to generate steam. The continued research over the past decade and the previous experiences of BCI have enabled Riley Stoker to produce AFBC industrial boiler designs with outputs from 50,000 to 500,000 PPH. These designs compare very favorably with oil fired boiler designs in terms of space requirement, environmental restrictions and simplicity of operation.

Two types of AFBC industrial boilers are illustrated in Figures 8 and 9. The overbed feed design, Figure 8, is applied for capacities under 100,000 PPH, whereas the underbed direct firing system is recommended for higher capacities in view of the inherent advantages.

The AFBC boiler design is very effective against sulphurous and nitric oxide emissions, and is versatile when applied with coals of different types and grades.

Retrofit capability is dependent upon original installation. Either overbed feed design or underbed direct firing design can be applied, depending on space availability beneath the boiler. Fluidized bed combustion, coupled with reinjection systems, provides a high combustion efficiency and a comparable FEGT (furnace exit gas temperature) thus assuring required superheat temperatures. Gas velocities of the order of 55-60 feet per second can be effectively applied for optimum convective heat transfer.

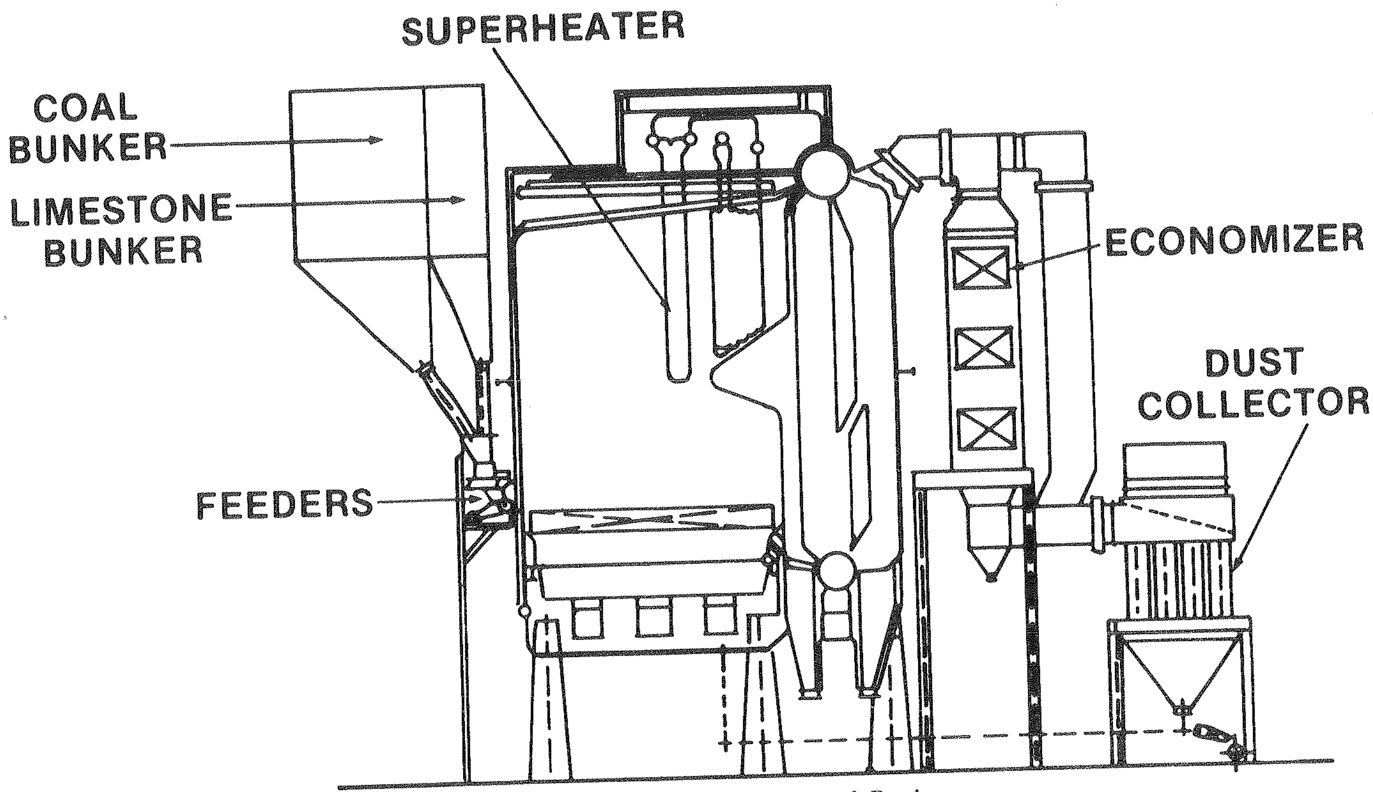

Figure 8 Typical Overbed Feed Design

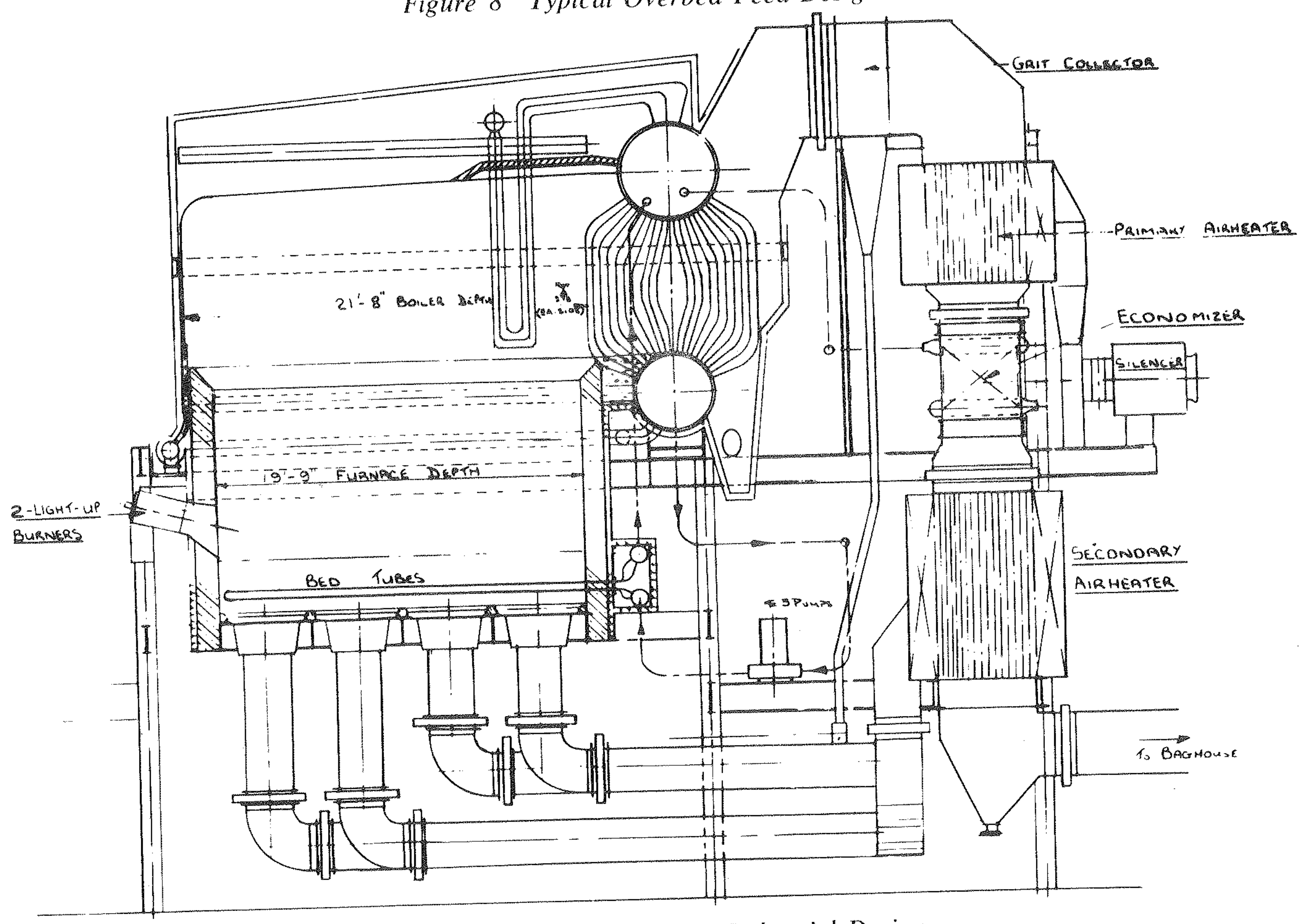

Figure 9 Medium Size Industrial Design

AUXILIARY EQUIPMENT

Various types of coal feeders have been developed. Their application varies with the type of feed control required. In effect, feeders provide a positive and accurate metering of coal without avalanching or overloading the distributor. A tramp metal capture provision integrated with feeders is a necessity when applied with pulverizers. Antisifting provisions assure prevention of overfeeding. Figures 10, 11 and 12 illustrate the three popular types of feeders normally associated with coal firing equipment.

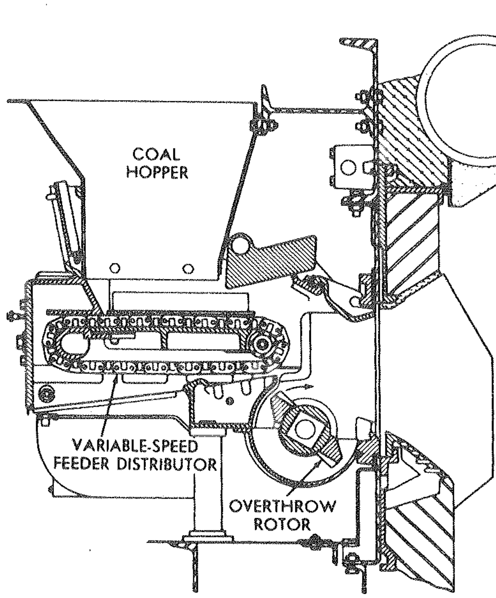

Figure 10 Variable Speed Chain Type Feeder

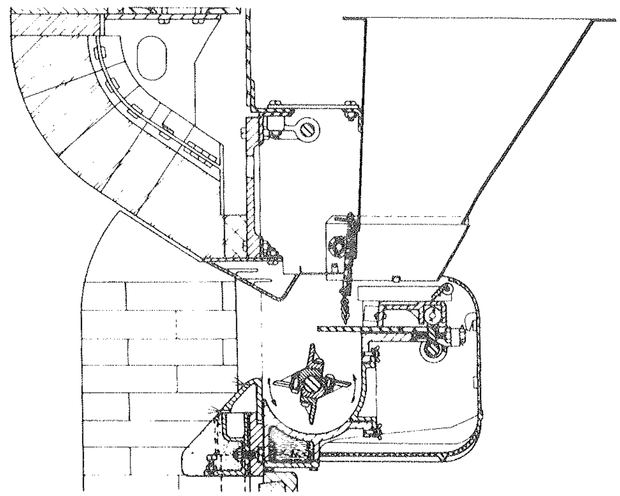

Figure 11 Riley Model "B" Feeder

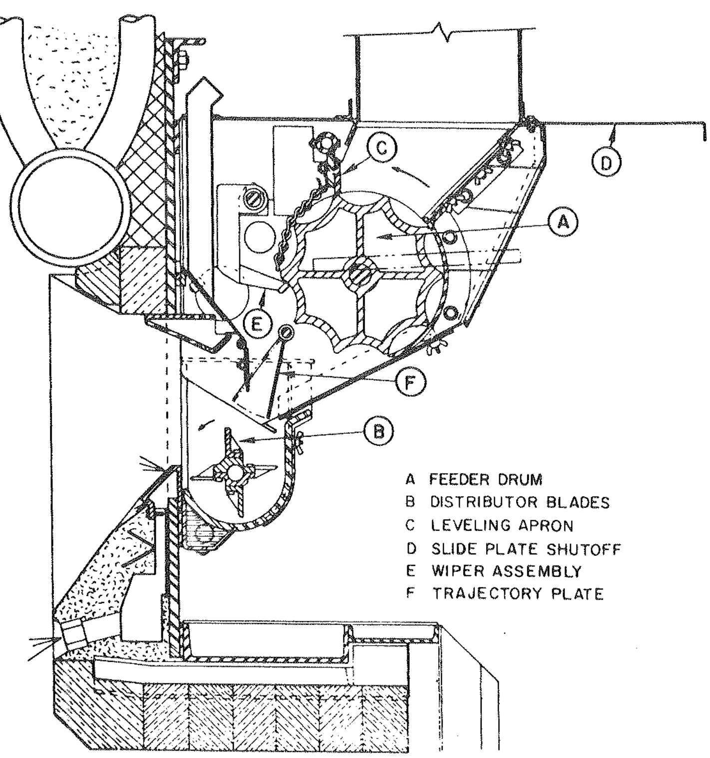

Figure 12 Riley Model "F" Feeder

EMISSIONS AND EMISSION CONTROL EQUIPMENT

Continuous awareness of health hazards related to stack emissions has resulted in stringent federal and state regulations. Whenever a change in fuel is contemplated, associated revisions in back end gas cleaning equipment become an essential part of such projects.

Current federal regulations exempt units under 250 million BTU/Hr. heat input ratings for oxide emissions. However, revision of these regulations to cover even smaller units is being considered. State and federal regulations should be thoroughly studied whenever conversion studies are undertaken.

Particulate Emissions

Depending on the mode of firing, the ash content in the fuel and system reinjection capability, boiler exit gases carry with them an appreciable amount of flyash in various sizes and compositions. Normally, with stoker-fired units, the carry-over is largely made up of particles greater than 30 microns; mechanical dust collectors could be adequate to meet the emission control regulations. In case more stringent regulations are to be satisfied, either particulate scrubbers, baghouses, or cold electrostatic precipitators would be necessary.

Sulphur Dioxide Emissions

Wet scrubbers have been the most popular installations which are considered to be effective in removal of SO_2 in the stack gases. Recent developments in the related industry suggest "spray-drying" applications as an alternate to wet scrubbers for sulphur removal.

Nitrogen Oxide Emissions

Current regulations restrict NO_x emissions in varying limits from a boiler, depending on fuel and heat input data. This regulation is applicable to only pulverized coal and coal gas fired units. Since stoker fired and fluidized bed combustion yield comparatively lower furnace exit gas temperatures, formation of excessive NO_x in the furnace is not anticipated. Regulation of NO_x emission can be very effective with overfire air into the furnace above the burners. Normally, the limits for NO_x emission with coal are set comparatively higher that that for corresponding oil- and gas-fired units. Under retrofit applications, NO_x regulation hardly poses any difficulty.

CONCLUSION

All of the factors discussed earlier, plus additional items, must be considered when converting an existing boiler from oil or gas to coal or back to coal. Following is an outline of the items that must be reviewed if coal firing is to be considered:

1. Steam output and temperature
2. F.D. fan capacity
3. I.D. fan capacity
4. Pulverizer capacity
5. Grate capacity
6. Burner capacities
7. Flame placement
8. Furnace slagging
   a. Furnace heat release rates
   b. Radiant superheater arrangement

9. Ash fouling (convection section)
10. Soot blowers
11. Ash removal system
12. Observation ports
13. Control systems
    a. Combustion control
    b. Burner management
14. Erosion in boiler passes
15. Low temperature corrosion
    a. Economizer
    b. Air heater
16. High temperature corrosion in superheater
17. Air pollution considerations
    a. Particulate
    b. Sulphur oxides
    c. Nitrogen oxides

With an engineering evaluation of the above factors, the considerations for conversion to coal firing will relate to the following corporate decisions:

a) Acceptability of derated output, if any.

b) Study of cost economics compared to replacement.

c) Coal availability of maintenance and operating costs.

The authors have attempted to acquaint the project and plant engineers with the design considerations necessary to formulate an evaluation of any approach towards coal conversion. It is believed that this paper has covered the many and varied areas enabling a judicious analysis of existing plants. Cost economics of such conversion projects varies with each installation and hence is not discussed within the confines of this paper. Riley Stoker Corporation will be very happy to assist plant engineers in determining the performance and cost economics relating to coal conversions.

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