AUTOMATIC COMBUSTION CONTROL OF MUNICIPAL SOLID WASTES AT OLMSTED COUNTY

by
F.A. PALACIOS
Manager, Instruments and Controls Department
RILEY STOKER CORPORATION
WORCESTER, MASSACHUSETTS

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RILEY STOKER
POST OFFICE BOX 547
WORCESTER, MASSACHUSETTS 01613

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ABSTRACT

The continual operation of modern incineration plants, especially when designed to generate power, demands reliability, consistent efficiency, and compliance with the environment.

Achieving such goals, demands a combustion process that is controlled and stabilized. Not too easy a task when one considers the inconsistency of the refuse/fuel substance and quality.

The Riley-Takuma automatic combustion control system (ACC) is designed exclusively for refuse incinerating systems. It has been developed over a considerable number of years. This paper will describe the system, its parameters, and its function, as applied to the Olmsted waste project.

INTRODUCTION

Riley Stoker Corporation is a well known American manufacturer and erector of steam generators and fuel burning equipment. Founded in 1913, it has traditionally served the utility and industrial market, domestic and foreign, with a variety of products. They range from central station boilers to specialized systems capable of burning the widest range of solid, liquid and pulverized fuels.

Takuma Company Ltd. is a Japanese manufacturer of boiler and fuel burning equipment. Founded in 1938, it enjoys a reputation unparalleled in its country for excellence in combusting municipal solid waste under rigid constraints of pollution control and energy demands.

In 1984, Riley acquired exclusive rights in the United States and all its territories to apply Takuma's mass burning technology at facilities utilizing municipal solid waste. This links the complementing technologies of Riley's industrial boiler design and Takuma's advanced waste burning grate systems.

The combustion of municipal refuse in incinerator-boilers and its control presents unusual challenges. They stem from the size distribution, caloric content, and moisture of the refuse fuel, all widely variable.

Changes in any or in all of these variables, if unaccounted for, will result in great unevenness and inefficiency of combustion. As a result, achieving the stability necessary to generate power would be next to impossible.

Since 1968 Takuma Ltd. Co. has sought ways of bringing this process under automatic control. By experimentation and practical application they have developed solutions truly innovative.

The aggregate result led to the development of the Takuma Automatic Combustion Control (ACC) that permits today the smooth generation of steam from municipal refuse, under automatic control.

Table I shows a listing of historic milestones in the development of the ACC system.

Year	
1968	Began investigations on sensing the finishing line of burning.
1971	Remote manual operation of grate speed and combustion air flow through TV monitoring.
1975	Automatic stoker speed control.
1976	Began experimentation on stoker speed control for steam flow stabilization.
1978	Began running ACC systems on actual refuse plants.
1980	Completed an ACC standard system design based on microprocessor technology.
1984	Began experimentation on low NO_X operation through ACC control.
1985	Began experimentation on auto-regressive model analysis through ACC control.

Table I Historical Development of the ACC System

The first application of the Takuma ACC system in the U.S.A. is scheduled for start-up in September, 1986 at the Olmsted County project in Rochester, Minnesota.

The Olmsted Waste-to-Energy has been designed to incinerate and convert to steam 100 tons of Municipal Solid Waste per day on each of two incinerator boilers rated at about 24,095 lbs. of steam per hour and operating at 615 psig and 650°F at the superheater outlet.

The steam will be used for both electrical generation and for service heating.

An air cooled condenser is capable of condensing all the steam generated by the plant, either from the turbine exhaust or from a turbine by-pass line, which includes pressure reducing and desuperheating stations.

The boiler controls are supplied by Riley Stoker Corporation and consist of two separate but integrated systems.

First the Takuma Automatic Combustion Control (A.C.C.) system specifically designed to control the combustion process and ensure evenness of steam generation. This system acts upon those elements related to the incinerating grates, namely, feeder and grate speeds and undergrate and overfire air flows. A description of this system is the main objective of this paper.

Second, the balance of boiler controls consisting of conventional loops such as controls for furnace draft, forced draft pressure, feedwater regulation, steam temperature and combustion and drying air temperature.

OPTIMIZATION GOALS OF REFUSE BURNING THROUGH COMBUSTION CONTROL

The conventional boiler, fired by natural gas, fuel oil or coal, typically controls steam generation by regulating the fuel and the combustion air flow in accordance with deviations from a steam pressure set point. This method is feasible because the heating values of fuels are accurately known and relatively constant.

On the other hand, incinerator boilers have to contend with the unpredictable heating value and moisture content of the refuse fuel. They vary not only seasonally but also change day to day and even hour by hour.

In these applications, there is seldom any attempt to maintain steam pressure constant by modulating the fuel rate. Steam generation is dictated by the refuse burning requirements and the steam pressure is kept relatively constant by either a back pressure regulator or by the action of the inlet valves to a steam turbine. The steam must be used or condensed as it is generated.

Only the averaging effect of the furnace's large capacity permits treating the given quantity of refuse on the grate as if it had a uniform caloric value. At least for enough time to achieve control of the steaming rate, provided that deviations from the expected heating value can be momentarily inferred from measured process variables.

Optimum combustion of municipal refuse requires that the following goals are achieved:

- Attainment of a stable combustion process.
- Attainment of evenness in steam generation.
- Ability to burn the required amount of refuse.
- Attainment of total combustion of burnables.
- Maintenance of an adequate bed level on the grate.
- Maintenance of noxious gases in the effluent within the prescribed limits.
- Minimization of human intervention.

Attainment of a stable combustion process under heterogeneous fuel size distribution, variable fuel heat value, and variable moisture conditions is critical. Otherwise we cannot ensure the automatic control of other variables such as furnace pressure, steam temperature and steam flow. Attaining this stability demands excellent coordination between the feeding of the refuse fuel to the combustion zone and the accurate injection of the required amount of drying and combustion air at the proper grate locations.

To achieve smooth turbine operation requires that steam generation be even. Sudden, unexpectedly large oscillations in steam flow may make it impossible for the turbine admission valves to maintain steam pressure and generator load syncronization.

The modern incinerator boiler is required to burn a certain amount of municipal refuse every day under automatic control. The automatic system should then be able to react to the prescribed loading information and position its final elements to ensure that the amount of refuse is completely burnt, with minimal intervention.

Total combustion of burnables is necessary to ensure not only total energy conversion effectiveness, but also the sterility of the resulting ashes.

Level on the grates must be maintained within specified limits. This will ensure uniform refuse movement, it will avoid accumulations, it will produce adequate drying, and it will promote air distribution.

Noxious gases should be kept within the limits prescribed by the Federal and local agencies. The control system should then be capable of adjusting the combustion process to minimize the formation of pollutants. Specifically NO_X, carbon monoxide, combustibles and solid particles at their formation stage.

Finally, the use of an adequate control system should result in minimizing human intervention. First, to reduce labor costs. Second, to prevent any human errors that may lead to expensive repairs and downtime.

THE ACC SYSTEM AN ADVANCED INCINERATOR-BOILER COMBUSTION CONTROL

The automatic combustion control system developed by Takuma addresses all of the goals expressed above. This has been demonstrated by its successful operation in several installations for a number of years.

This system takes advantage of microprocessor technology to perform high speed calculations, to provide for simplified interface with the operator, and to collect and display necessary process data.

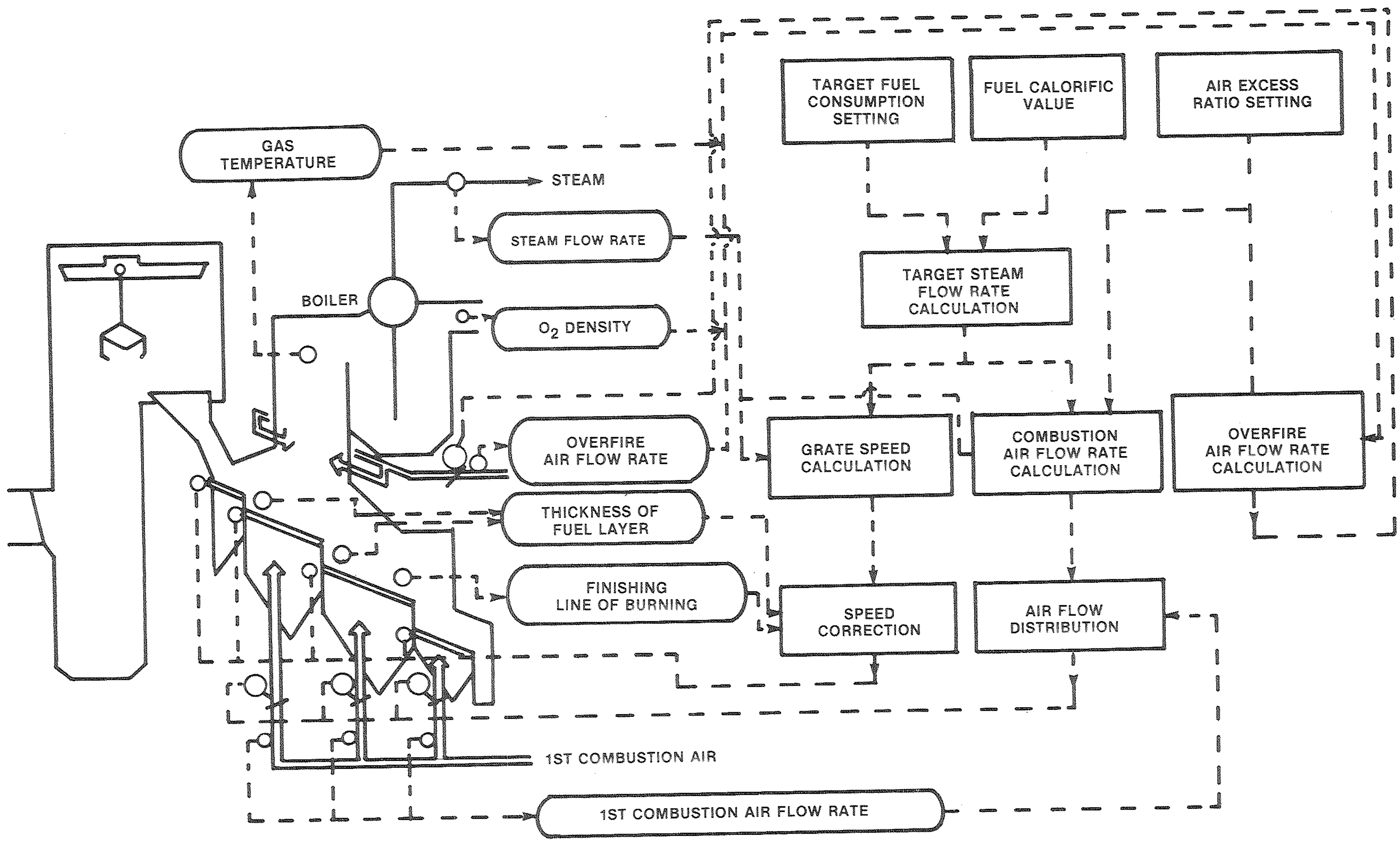

Figure 1 Automatic Combustion Control System

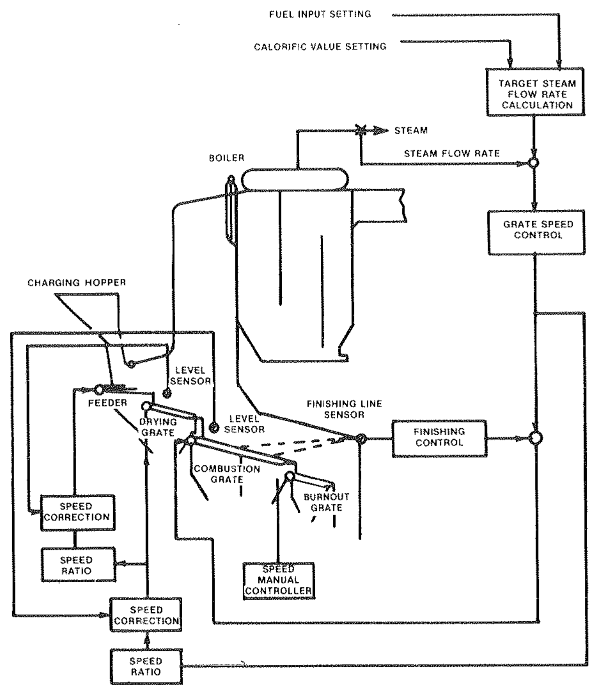

Figure 2 Schematic diagram of grate speed control system

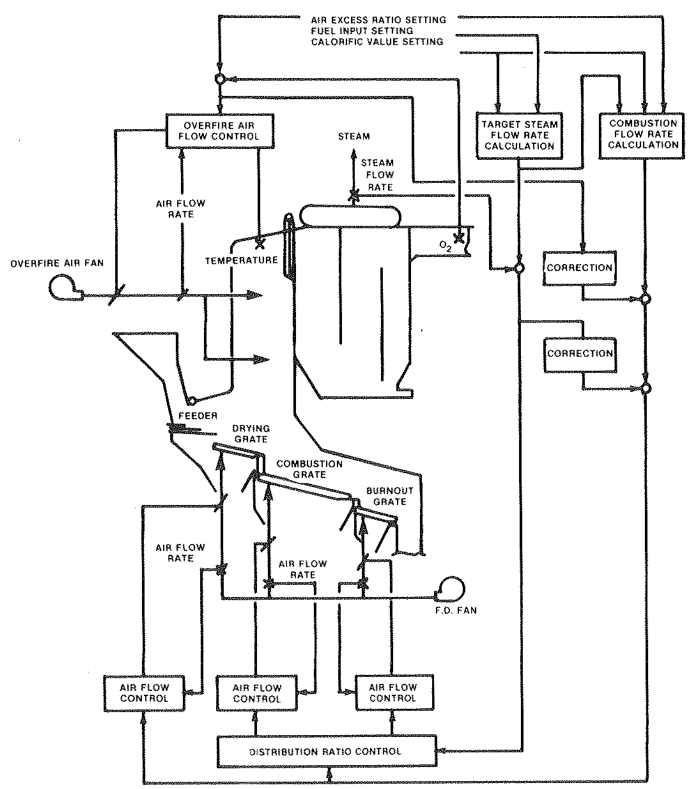

Figure 3 Schematic diagram of combustion air and low oxygen control system

Figure 1 shows the overall control block diagram and Figures 2 and 3 show the two main control loops in their relation with the stoker physical arrangement.

The control system can be divided into separate components:

- Steam flow calculation
- Grate speed
- Combustion air flow
- Fuel consumption control
- Oxygen control
- Furnace outlet flue gas temperature control

Steam Flow

Dialed-in estimates of the average refuse heat value and the hourly amount of refuse to be burned enables the control system to calculate the "target steam flow" setpoint pattern for that day.

Any deviations from the target steam flow caused by variations in refuse heating value and/or moisture content are detected and corrected by the grate speed and combustion air controllers. Measured steam flow is actually the basic feedback signal representing the average heat release in the furnace.

Grate Speed Control

The grate speed controller further corrects the grate speed demand signal by feedback information from the process.

A specially designed light quantity sensor located at a prescribed location above the combustion grate determines if luminosity is adequate at that location to provide complete combustion of the refuse. If light intensity is greater than expected the combustion grate is slowed down to delay the combustion, and viceversa.

The fuel thickness must also be kept at the optimum level for proper drying and burning. Thus, signals from two microwave type level detectors located at the drying grate and at the combustion grate further trim the feeder and drying grate speeds as necessary.

Finally, the basic relationship between feeder speed, drying grate speed and burning grate speed is manually set in agreement with the fuel characteristics.

Combustion Air Flow Control

The requirements for combustion air flow are determined by the air flow controller in agreement with the target steam flow and a manually selected value of excess air ratio. The measured steam flow corrects this value to generate a demand signal for actual air flow requirements. The control system calculates the distribution requirements between drying air and combustion air.This ratio is automatically controlled by modulating the undergrate air control dampers, under closed loop control, and based on the actual measurements of air flow to each grate.

Target Fuel Consumption Control

The ACC system provides for more than even steam flow generation. By calculating target steam flows based on estimated heat content and hourly refuse quantity, the ACC also facilitates the programmed, automatic disposal of the required quantity of refuse on a given day.

Low Oxygen Control

Overfire air flow is determined by the excess air requirements. A measured oxygen trim circuit corrects the overfire air flow, and simultaneously the undergrate combustion air. Maintaining the proper O_2 level by manipulating the overfire air, limits NO_x generation effectively.

Furnace Outlet Flue Gas Temperature Control

Overfire air flow is also used to limit flue gas temperature excursions, thus the basic overfire air oxygen control is further corrected. The correction is based on measured flue gas temperature information.

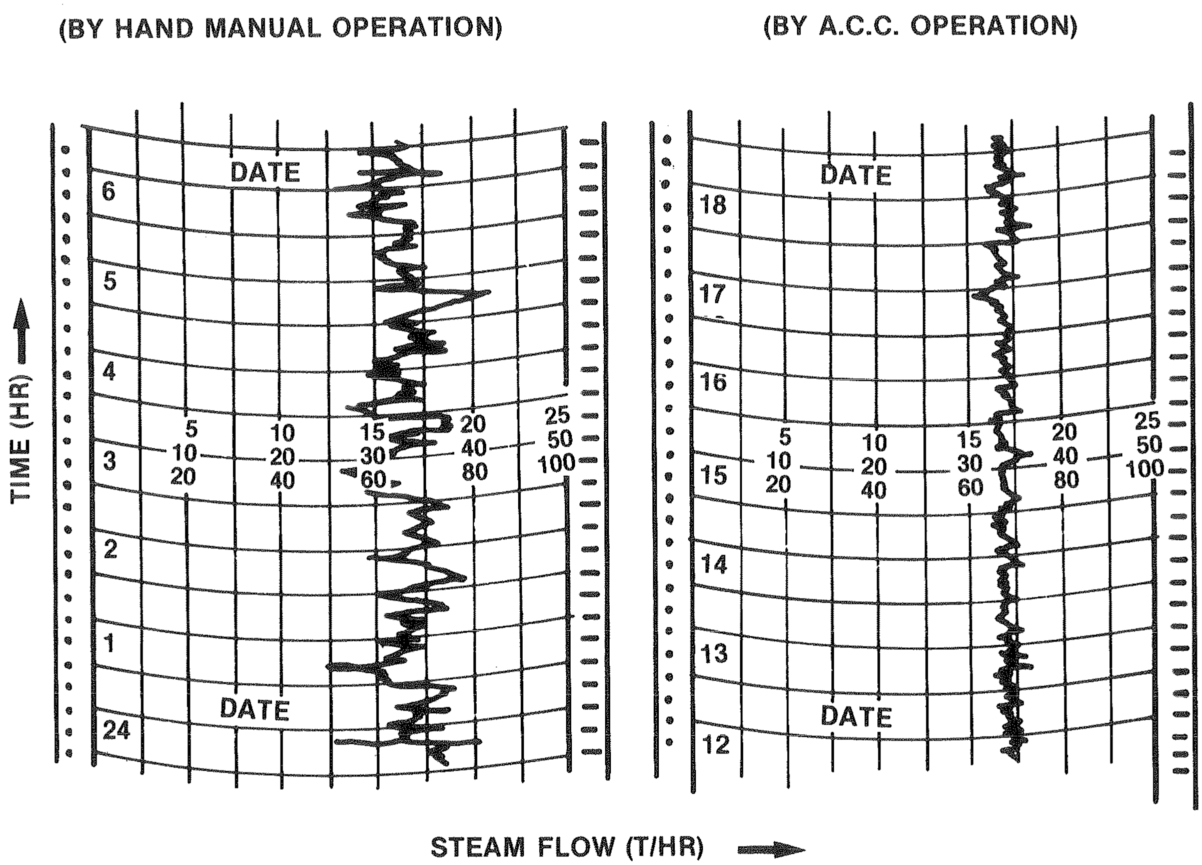

Figure 4 An example of steam flow charts

Example of Operating Data

Figure 4 shows a comparison between actual recordings of steam flow variation on an incinerator-boiler under hand control and the same furnace under automatic ACC control. A definite improvement is evident.

Figure 5 shows a composite of the physical appearance of the system and Figure 6 shows the microwave level detector.

OLMSTED WASTE CONTROL DESCRIPTION

The Riley/Takuma control system consists of the following components: (See Figures 5 and 6).

A control cabinets containing factory mounted microprocessor based high speed computing cards, power supplies, input output cards and manual control stations used for maintenance purposes. This control cabinet is approximately 2′W × 2′D × 90″H.

In the above cabinet terminate the field signals associated with the combustion control, namely: Steam flow, combustion air flow, drying air flow, burn out air flow, overfire air flow, combustion grate luminosity, drying grate level, combustion grate level, furnace exit temperature, and oxygen concentration.

Outputs from this gravel modulate, on a continuous basis, the feeder and grate speeds, and the undergrate and overfire air flows.

A insert panel containing an alpha numeric display, control push-buttons and computer style key pads for proper operator interface and status information. This insert is approximately 15″ W × 3″D × 10″H.

A separate insert panel contains all feeder and grate start-stop control stations and monitoring lights. This panel is also 15″W × 3″D × 10″H.

The balance of boiler control system: feedwater, furnace drafts, F.D. fan outlet pressure, steam temperature control and air temperature, steam coil air heater control consists of conventional micro processor based Fisher Provox controller cards housed on controller files racks and located in the main control board.

Automatic grate cleansing is provided by compressed air through 3 sets of solenoid valved, one set per grate, connected at locations under the grate clips. A sequential controller ensures the periodic opening of each solenoid valve.

Figure 7 depicts the analog control loops of the Takuma ACC system and the conventional balance of boiler controls for Olmsted Waste.

CLOSURE

As demonstrated in multiple applications, the automatic combustion control system (ACC) developed by Takuma offers an innovative and proven solution to the very complex problem of stable combustion and automatic control of incinerator boilers.

Approximately sixty four boiler incinerators in thirty different locations have been ordered. Forty eight are operating successfully. Sixteen are under construction, two of these at the Olmsted Waste facility in the U.S.A.

Table II shows a listing of ACC boiler-incinerator systems. All the operating plants have evidenced customer satisfaction for the following reasons:

- Maximization of steam production
- Control of pollutants
- Evenness of steam/electricity generation
- Reduced operator involvement

This is a critical time. A time when the United States must move away from its inefficient and wasteful disposal of municipal refuse and turn to the energy recovering and ecological sound methods offered by the boiler-incinerator systems. At this crucial time, the proven Takuma ACC combustion control offers American technology a positive and welcomed contribution.

REFERENCE

1. Langone, J.A., "Riley Stoker in Resource Recovery," Presented at the International Small-Scale Municipal Waste-to-Energy Conference, Washington, D.C., February 1985.

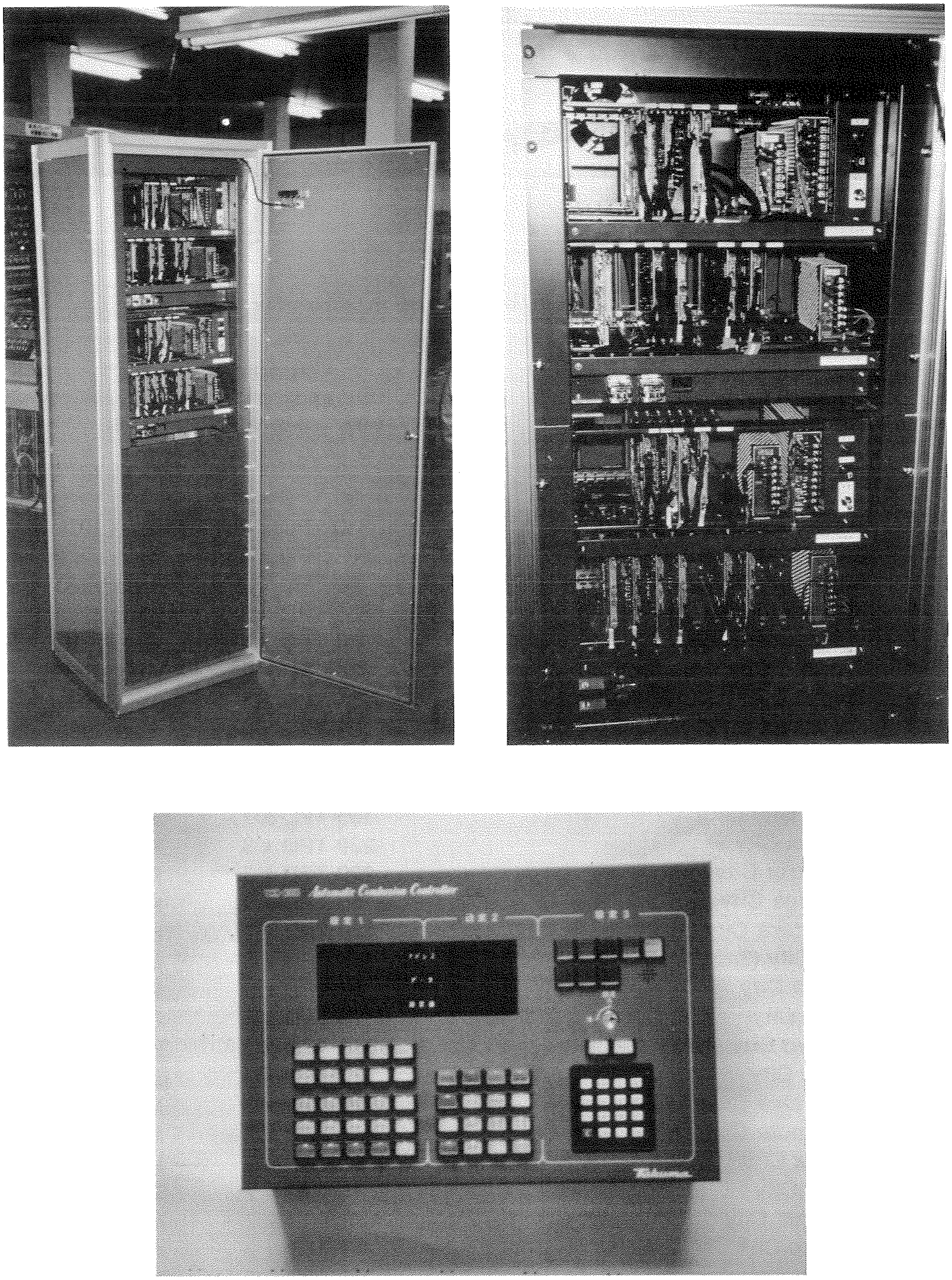

Figure 5 Physical appearance of ACC Control System

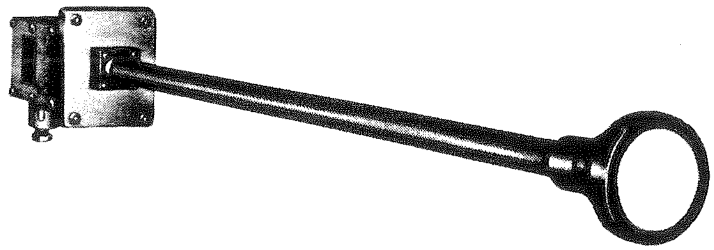

Figure 6 Fuel layer thickness sensor (microwave type)

NO.	CUSTOMER	PLANT CAPACITY TPD x TRAIN	COMPLETION DATE
1	Nissan Motor	55 TPD x 1	Sep. 1973
2	Shimonoseke City (Akada)	99 TPD x 2	Mar. 1975
3	Sapporo City (Atsubetsu)	330 TPD x 2	Sep. 1976
4	Kagoshima City (Northern)	165 TPD x 3	Mar. 1978
5	Koriyama City (2nd)	99 TPD x 2	Mar. 1980
6	Nagoya City (Nanyo)	330 TPD x 3	Nov. 1980
7	Yamaguchi City	66 TPD x 2	Oct. 1980
8	Sapporo City (Shinoro)	330 TPD x 2	Aug. 1980
9	Shimonoseki City (Okuyama)	165 TPD x 1	Mar. 1980
10	Kanazawa City	193 TPD x 2	Sep. 1980
11	Hamamatsu City	165 TPD x 2	Feb. 1981
12	Ebetsu City	83 TPD x 2	Mar. 1981
13	Urawa City (3rd)	165 TPD x 1	Jun. 1982
14	Toyama City	220 TPD x 3	Mar. 1983
15	Yokosuka City	220 TPD x 3	Mar. 1983
16	Ashikaga City	110 TPD x 3	Mar. 1983
17	Matsuzaka City	110 TPD x 2	Mar. 1984
18	Soka City (3rd)	165 TPD x 2	Mar. 1985
19	Fujieda City	94 TPD x 3	Mar. 1984
20	Gyoda City	75 TPD x 2	Oct. 1984
21	Sapporo City (4th)	330 TPD x 2	Mar. 1985
22	Mitaka City	72 TPD x 3	Sep. 1984
23	Wakayama City	220 TPD x 2	Mar. 1986
24	Kumamoto City	248 TPD x 2	Mar. 1986
25	Fujioka City	99 TPD x 2	Mar. 1986
26	Fujimi City	44 TPD x 2	Mar. 1987
27	Kawagoe City	77 TPD x 2	Nov. 1986
28	Mitsuke City	33 TPD x 2	Aug. 1986
29	Kahoku County	55 TPD x 2	Apr. 1987
30	Olmsted Waste, Minnesota	100 TPD x 2	Sep. 1986

Table II Takuma ACC boiler incinerator systems

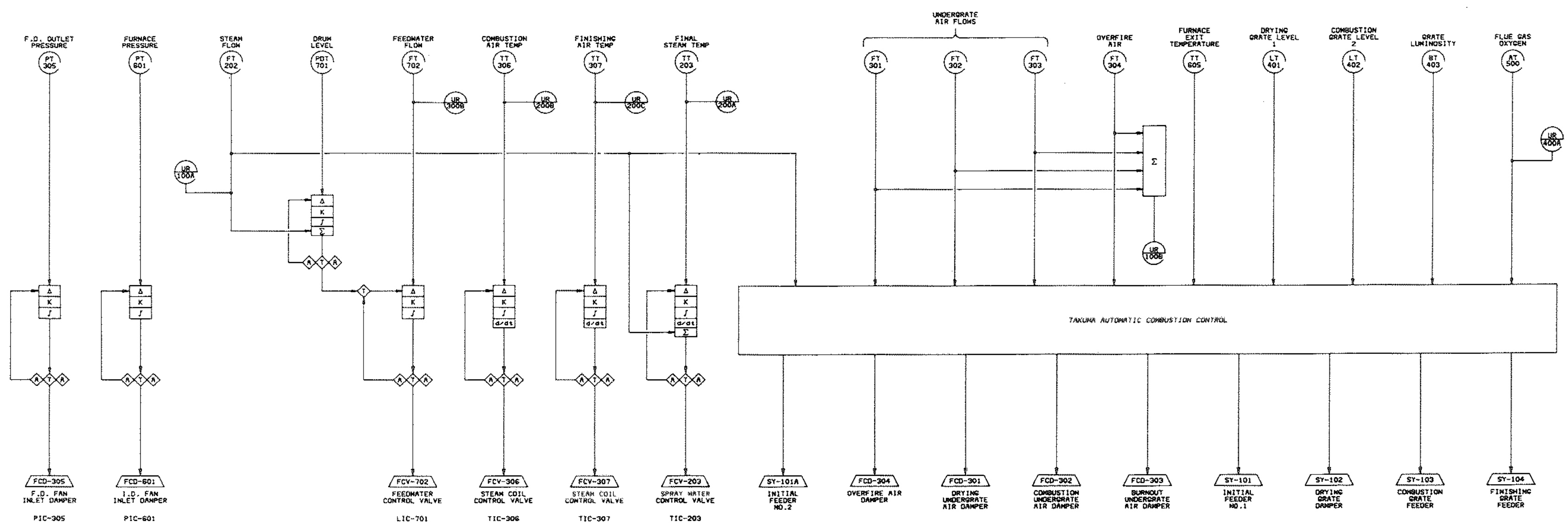

Figure 7 Boiler Analog Control Diagram