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COMMUNITY HEAT AND POWER STATION IN BERNE

FIRST-EVER COMBINATION OF GARBAGE INCINERATION HEAT SUPPLY AND OPTIMUM POWER GENERATION WITH HIGH-DUTY RADIATION BOILERS

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Winterthur, Switzerland

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(Editor's note: Extensions as indicated by dotted lines in Fig. 2 and additional ones are now in progress. Plans to more than double the present boiler capacity by 1973 are being finalized)

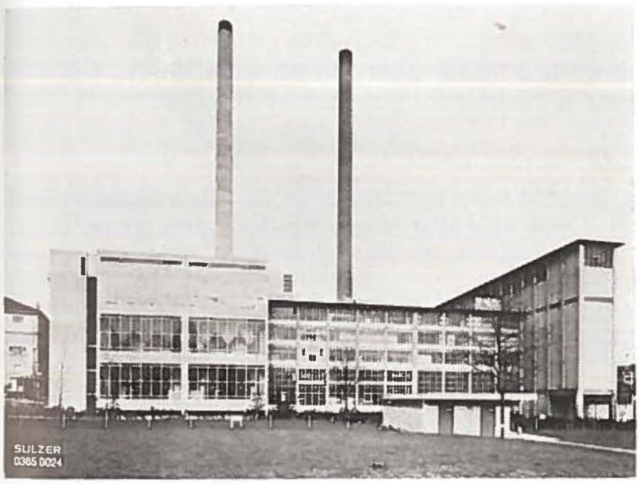

FIG. 1—General view of the Berne district heating and power station, showing boiler house (left), steam turbine bay and heat station with tall stack (middle) and garbage bunker (right). Concealed behind the middle section is the building with the two garbage incinerators and the wasteheat boilers with tall stack.

Since 1954 the garbage incineration and district heating station in Berne, with an installed thermal output of 19 million kcal/h, has been in continuous operation. The sudden development in steam generation caused by the contantly increasing volume of garbage subsequently became an embarrassment and involved significant loss of income. However, the appearance of new large consumers on the scene soon reversed this situation. Heat had to be supplied to the extensions to the Inselspital, the large buildings in course of erection for the Swiss Federal Railways and the Post Office in the area of the railway station, and to various other large consumers (Fig. 2). All these potential consumers were not merely interested in taking part of the surplus heat chiefly available during the summer months, but rather in constantly taking heat mainly during the winter. These considerations rendered imperative expansion of the boiler plant and construction of a district heating system. Our company was consequently entrusted with working out a general project for the purpose of clarifying the technical possibilities available for expansion of the existing district heating and power station and examination of the financial and economic aspects. The oft-repeated recommendation that the reserve boiler capacity needed for operational reasons be used for the generation of valuable winter energy was put into practice. On the basis of the project data, at the end of 1960 the electors of Berne voted for expansion of the district heating station into a combined district heating and power station; it was taken into operation as early as 1963/64 (Fig. 1).

Plant Layout

Figs. 3 and 4 illustrate the fundamental layout of the district heating and power station. The northern section accommodates the radiation boiler plant whose flue gases are discharged through a stack 85 metres high. Further to the north is the cooling tower installation with forced draught equipment for the condensing turbine. A 10,000 kW condensing turboset and a 2,400 kW backpressure turboset are available in the machinery bay for generation of electric power. In the topmost storey there are two feedwater accumulators with a capacity of 50 m^3 each fitted with deaerator, and a demineralization plant. Behind these and above the accumulators are four steam/HTHW cascade transformers. For partial recovery of surplus heat generated by the garbage incineration plant during the summer months a small backpressure turboset with a rating of 200 kW and also serving as emergency generator set is installed. Also provided for heating purposes is a steam/hot water transformer, while a steam/cold water transformer is installed for recovering surplus heat.

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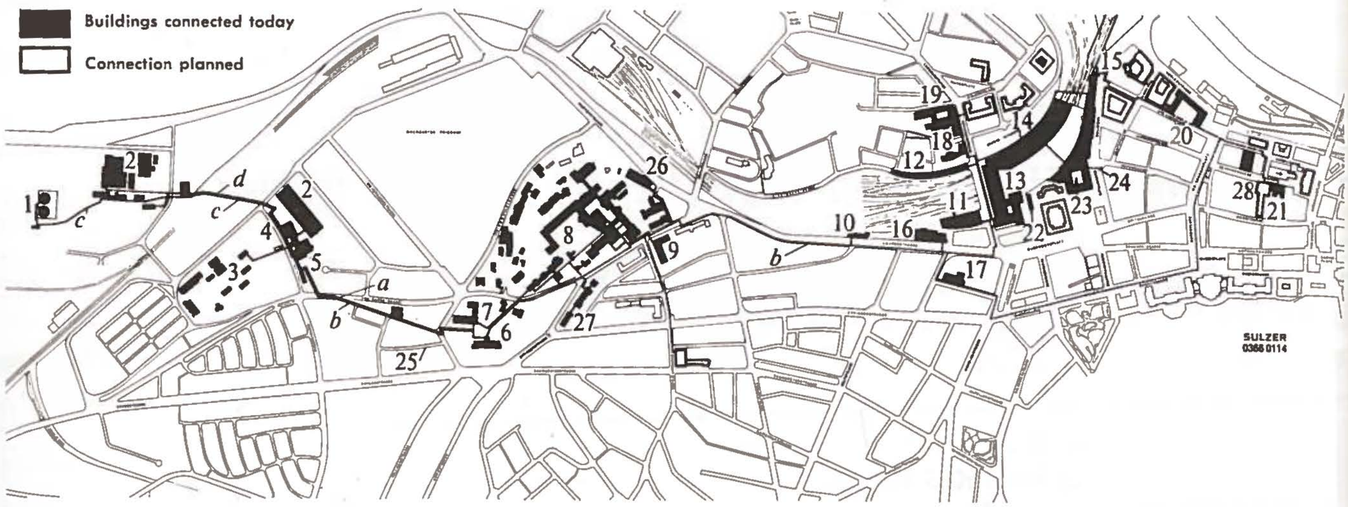

FIG. 2—Location of the consumers supplied with heat by the Berne district heating and power station and the buildings it is planned to connect to the system.

1 Oil tank installation
2 Industrial consumers
3 Steigerhubel Schoolhouse
4 Boiler and turbine house
5 Garbage incineration plant
6 Lory-Spital I
7 Lory-Spital II
8 Inselspital
9 Dental Institute
10 Signal box
11 Post office station
12 Railway building
13 Schanzenpost
14 Park terrace
15 Office building, CFF signal box
16 Communal dairy
17 Swimming bath
18 Superior Court
19 Cantonal Women's Hospital
20 Progymnasium
21 Volkshaus
22 Burgerspital (new building)
23 Reception building
24 Shopping underpass
25 Freiburgstrasse 57
26 Elitegarage
27 Jenner Children's Hospital
28 Business building, Nageligasse 7
a HTHW line I to Inselspital
b HTHW line II to railway station area
c HTHW line III to tank installation
d Steam line to industrial consumers

Schematic of the Plant (Fig. 5)

The two feedwater accumulators are supplied with water from the return line of the district heating system and from the condenser of the 10,000 kW turboset via a gas expeller. The makeup water needed to cover the loses and to compensate direct steam consumption also passes to the deaerator via a vapour condenser. A demineralization plant treats ground water or water drawn from the town mains. From the feedwater accumulators the deaerated water flows to the radiation boiler feed pumps and then through these into the boilers via a valve. One pump driven by electric motor is provided for each boiler, and a pump driven by steam turbine is installed as standby for the two boilers. Steam generated in the boilers is fed to a distribution header and then either to the two turbosets or to the steam pressure and temperature reducing station. Steam from the backpressure turbine, from the reducing station, the two waste-heat boilers and from the Velox and three-pass boilers is fed to the steam accumulator with a service pressure of 10 atm. gauge and then enters the HTHW transformer. The high-temperature hot water produced has a temperature of 180 C and is fed either to the four constant-pressure HTHW accumulators or directly to the consumers via the HTHW distribution system pumps. After the HTHW has cooled down to 80-140 C, circulation pumps deliver it either to the cascade transformers or return it directly to the feedwater accumulators. Part of it is diverted to the feedwater accumulators, while the remainder is fed to the waste-heat Velox and three-pass boilers via a booster pump.

Generation of Heat

Taking into consideration existing connections and the planned extensions as well as new consumers, the total connected heat load is about 77 million kcal/h. The following plant is available for generation of this heat:

In the 1953 plant:

2—SLM waste-heat boilers in the two incinerators, each with an output of 6 tonnes/h, 11 atm. gauge, 210 C, and

1—Velox boiler with a rating of 7 tonnes/h, 11 atm. gauge saturated steam.

In the additional 1963 plant:

2—Sulzer MP radiation boilers, each with an output of 32/40 tonnes/h, 59 atm. gauge, 475 C,

1—Sulzer three-pass boiler with an output of 9 tonnes/h, 11 atm. gauge saturated steam.

In view of the probable future increase in the quantity of garbage to be incinerated, provision has been made for the installation of further incinerators as well as a third radiation boiler with a capacity of 32/40 tonnes/h.

Radiation boilers were selected because they ensure that a variety of fuels can be fired, including those of low quality, since it is important to maintain the supply of heat to the hospitals even if there are difficulties with imported fuels. Moreover, in order to avoid emission of soot and fly ash a method of firing had to be chosen which makes possiadequate cleaning of the exhaust gases by means of cyclone separators. The single-drum high-duty radiation boilers requiring very little brickwork are of a design developed by our company more than 25 years ago and continuously and systematically perfected; numerous boilers of this type have been installed at home and abroad and have constantly given good service.

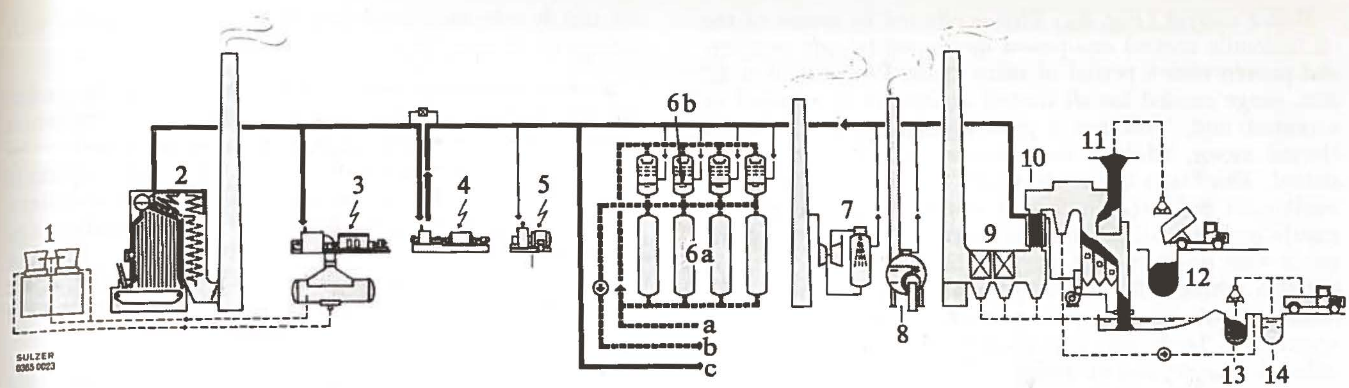

FIG. 3—Schematic of the garbage incineration plant and the district heating station.

1 Cooling towers
2 Radiation boiler, 32/40 tonnes/h, 59 atm. g.
3 Condensing steam turbine, 10,000 kW
4 Backpressure turbine, 2,400 kW
5 Emergency generator set, 200 kW
6a Accumulators
6b Cascade transformers
7 Velox boiler, 7 tonnes/h, 11 atm. g.
8 Three-pass boiler, 9 tonnes/h, 11 atm. g.
9 Electrostatic filters
10 Waste-heat boiler, 6 tonnes/h, 11 atm. g.
11 Garbage incineration furnace
12 Garbage bunker
13 Slag bunker
14 Settling tank
a HTHW return, 90—140 C
b HTHW flow, 180 C
c 10 atm. g. steam feeder

Characteristic for this type of boiler are uncomplicated and neat layout, simply routed water circulation, good efficiency, a relatively high combustion chamber entirely surrounded by a large radiant heating surface with closely-spaced tubes, and a contact surface located in the low temperature zone and largely preventing baking of slag. Further advantages are the large furnace with generously dimensioned radiant heating surface, the practically designed contact and radiant superheaters and the favourably dimensioned evaporator economizer followed by air preheaters. Special attention has been paid to ensuring unhindered expansion of the freely suspended tube system.

All the boiler tubes lining the furnace are rolled into a single boiler drum at the top and welded into headers fed by downcomers at the lower end. With the exception of the relatively thin refractory slabs between risers and downcomers in the combustion chamber and the lining of the hoppers, there is no refractory brickwork. Moreover, conventional brickwork is replaced by asbestos and slag wool with sheet metal cladding. Together with the relatively low water capacity, this results in very low thermal inertia. This is supplemented by the ability to follow load fluctuations rapidly and, in emergencies, to start up very quickly.

One special advantage of these boilers is their high efficiency over a wide load range, combined with high flexibility during startup and in steam output; for example, during tests with coal and oil firing continuous efficiencies of up to 93% (guaranteed efficiency 90%) were measured under normal load of 32 tonnes/h on heavy oil, while under quarter load it was still 86%.

Two Sulzer oil burners with pressure atomization are installed above the traveling grate in the front wall of the boilers. Each burner, which can atomize up to 1,600 kg of oil per hour, is fitted with a servomotor by means of which the two burners can be regulated together or separately from the boilerman's position. The oil flow rate and the volume and spin of the combustion air can also be regulated by this means. Without it being necessary to change the burner nozzle the burner design ensures proper operation with minimum combustion air surplus over a sufficiently large load range. When oil is being fired the combustion air is taken from the forced-draught duct beneath the grate. In order to prevent low-temperature corrosion occurring when sulphurous fuel oils are fired, each burner is fitted with equipment for the injection of dosed quantities of magnesium oxide. From the combustion chamber the flue gases pass via a convection bundle and the final superheater from above into the second pass in which are installed the presuperheater, below this the evaporator economizer and, right at the bottom, the economizer. In the hopper arranged beneath the economizer and air preheater the flue gases are reversed through 180 degrees, initial coarse dust separation being effected. The flue gases then flow round the air preheater, pass through the two Sulzer-Van Tongeren double cyclone separators to the flue gas fan and then into the exhaust stack.

Fuel supply: Apart from the guarantee fuels, a wide range of fuels of various qualities and origin can be fired in these boilers, although partly at the expense of performance and some modifications. Fuels that can be economically fired in addition to fuel oils of various origins ranging from Bunker C to gas oil include steam coal, long-flame gas coal, bituminous coal, fat coal, semi-bituminous and lean coals as well as hard coal, lignite and coke fines.

Two tanks with a capacity of 10,000 m³ each are availabld for storage of fuel oil at a distance of 600 metres from hen station. Heavy fuel oil is heated in the tanks by HTHW lers. fed through a heated pipe to a day tank recessed into tili- ground and having a capacity of 150 m³. It is transferred from this tank by pump to the fuel oil supply plant beneath the boiler control panel. There are also two underground tanks, also with a capacity of 150 m³ each, for light oil for the Velox boiler.

The equipment for supplying fuel oil comprises a screw pump driven by a squirrel-cage motor, a relief valve, a dual filter with three-way cock, and an oil preheater for heating the fuel oil to about 130 C.

For firing the boilers with coal or coke, bins with a capacity of 660 m³ are provided in the boiler house; they are supplied by a pendulum bucket conveyor installation. Coal then passes via weighers to the traveling grates. Wet slag is transported by the said handling equipment into a bin near the boiler house for removal by motor truck.

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Boiler control (Fig. 6): This is effected by means of the oil-hydraulic control equipment developed by our company and proven over a period of many years. Pressure oil at 12 atm. gauge needed for all control equipment is supplied by a central unit. This has a gear-type oil pump driven by electric motor, while a steam-driven standby pump is installed. This starts up automatically when needed. Pressure oscillations produced in the oil system by an exciter constantly maintain all control equipment oscillating about the steady-state position. This not only eliminates static friction, but also substantially improves the accuracy of control. The boiler control equipment comprises no less than five control systems, i.e. feedwater, live steam temperature, air pressure, induced draught and oil firing.

Monitoring instruments: All measuring and monitoring instruments for monitoring and controlling the firing equipment, flue gas, water, steam and fuel oil systems are accommodated in a control console arranged on the front wall of the boiler. Each boiler has its own panel, while a further panel contains the plant instrumentation. Apart from the usual instrumentation the panel also accommodates the switches for setting the boiler load, the grate speed, correction of the combustion air flow rate, a charge state indicator for the HTHW accumulators and a load indicator for the condensing turboset.

Auxiliary equipment: The two feedwater tanks with a capacity of 50 m³ each and fitted with deaerators designed for an output of 60 tonnes/h are arranged horizontally about 10 metres above the boiler house floor. From these vessels the deaerated feedwater flows under gravity to the feed pumps behind the boilers. Each boiler is fed by a motor-driven feed pump with an output of 48 tonnes/h. A standby turbine-driven pump with a rating of 128 tonnes/h is also available for the two boilers jointly.

Combustion air is supplied by a low-pressure centrifugal fan driven by an 85 h.p. slipring motor. A similar motor with a rating of 170 h.p. drives a medium-pressure centrifugal fan for extraction of the exhaust gases. The secondary air and fly coke fans are driven by squirrel-cage motors wi ratings of 13 and 7 h.p.

Further auxiliaries include the shot cleaning equipme for the heating surfaces following the main combustic chamber; this equipment employs a centrifugal fan drive l a 40 h.p. squirrel-cage motor. The granulate with a partic size of 4 to 6 mm is fed pneumatically into the shot collec ing tank on the roof of the boiler and fed intermittently the second and third flue gas passes. The action of the sh effectively removes soot and ash from the tube walls. Aft filtration and screening, an ejector returns the shot to tl collecting tank.

All pipework length are welded together, flanges beir fitted only for connection to apparatus and fittings. Li steam lines and final superheaters are of special alloy stee All vessels, lines, flue-gas and hot air ducts, flue gas fans an dust separators are insulated with slag wool and metal cla

Feedwater treatment: The boilers are fed with wat drawn from the district heating system. In order to preve high blow-down losses a demineralization plant is installe for the treatment of makeup water to replace losses in tl steam and HTHW systems and in the consumers. The trea ment plant consists of two parallel units with a capacity c 12 m³/h and followed by conditioning with hydrazine an phosphate to protect the HTHW system against corrosion.

Treated water passes from this plant via two vapour co densers to the deaeration section of the two feedwater acc mulators with a capacity of 50 m³ each. It is then mixe with the heated condensate from the 10,000 kW turbine an part of the return water from the HTHW system and is the deaerated.

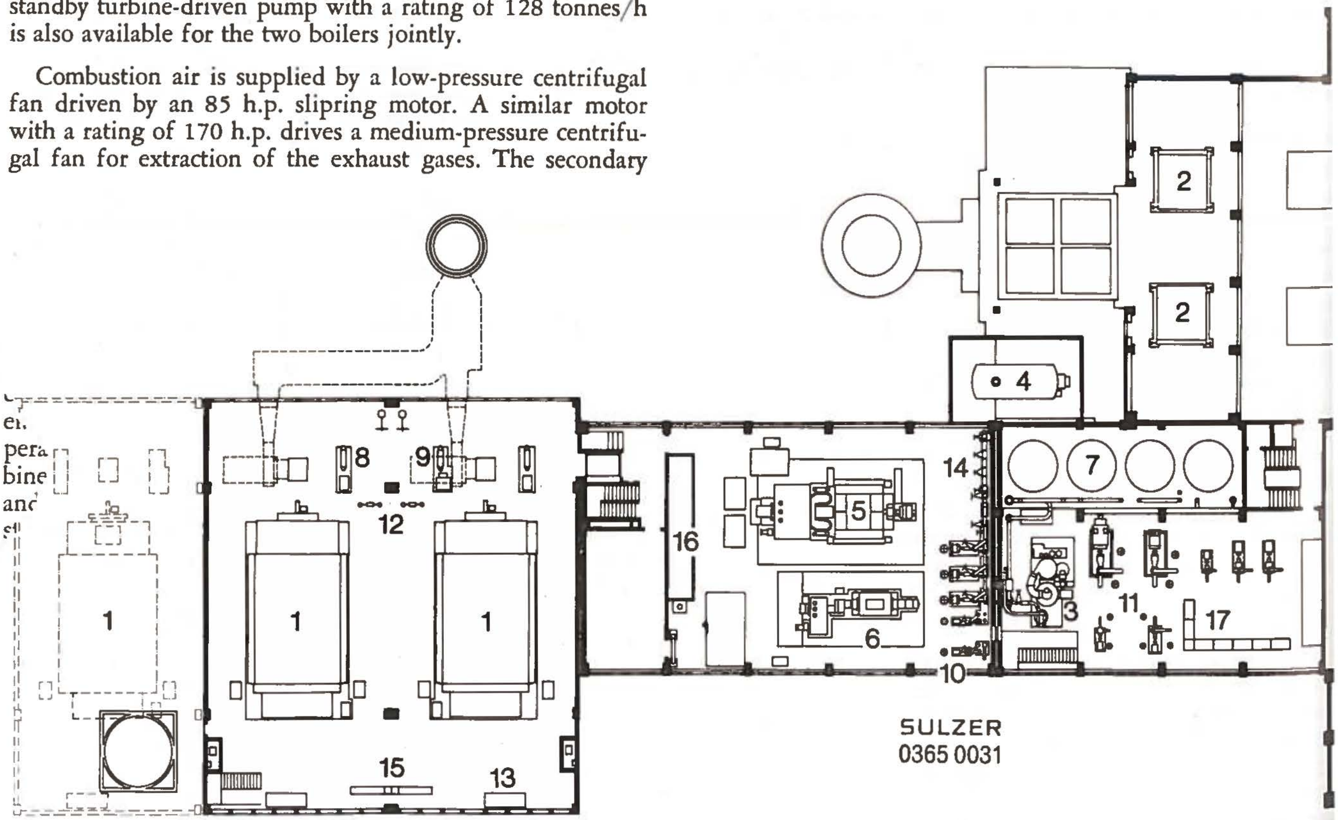

FIG. 4—Plan of the heat station.

1 Radiation boiler
2 Waste-heat boiler
3 Velox boiler
4 Three-pass boiler
5 Condensing steam turbine, 10,000 kW
6 Backpressure turbine, 2,400 kW
7 HTHW accumulator
8 Motor-driven feedwater pumps
9 Turbine-driven feedwater pumps
10 Cascade circulating pumps
11 HTHW feed pumps
12 Feedwater control valve
13 Firing control
14 Circulating control valves
15 Boiler monitoring panel
16 Turbine monitoring panel
17 Telemetering equipment, heat meters

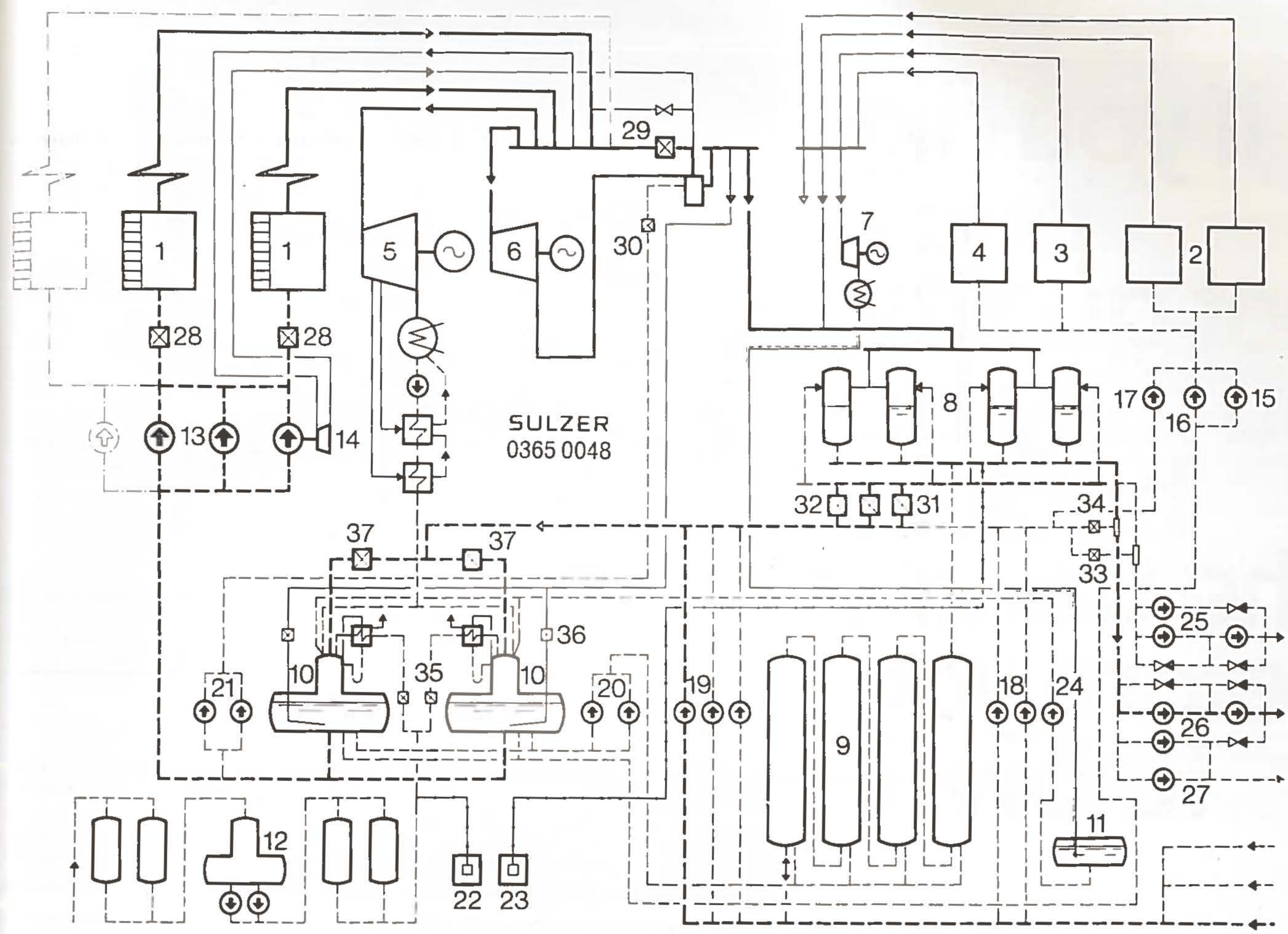

FIG. 5—Schematic of the plant.

1 Radiation boilers, each 32/40 tonnes/h, 59 atm. g., 475 C
2 Waste-heat boilers, each 6 tonnes/h, 11 atm. g.
3 Velox boiler, 7 tonnes/h, 11 atm. g.
4 Three-pass boiler, 9 tonnes/h, 11 atm. g.
5 Condensing steam turbine, 10,000 kW, 40 tonnes/h, 58 atm. g., 465 C
6 Backpressure turbine, 2,400 kW, 30 tonnes/h, 58/11 atm. g.
7 Emergency generator set, 200 kW
8 Cascade transformers, each 20 million kcal/h, 10 atm. g.
9 HTHW accumulators, each 100 m^3, 180 C
10 Feedwater storage tanks with deaerator, each 50 m^3
11 Storage vessels, 50 m^3
12 Demineralization plant, 2 x 12 tonnes/h
13 Motor-driven feed pumps
14 Turbine-driven feed pump
15 Motor-driven feed pump, 11 atm. g. boilers
16 Turbine-driven feed pump, 11 atm. g. boilers
17 Return feed pump, 11 atm. g. boilers
18 Accumulator charging pumps
19 Accumulator charging pumps
20 Accumulator topping pumps
21 Injection pumps
22 Phosphate dosing equipment
23 Hydrazine dosing equipment
24 Condensate pump
25 District heating pump, line 1
26 District heating pump, line 2
27 District heating pump, line 3
28 Feed control
29 Steam pressure reducing valve
30 Injection control
31 Circulating control valves, each 150 tonnes/h
32 Circulating control valve, 300 tonnes/h
33 Temperature control valve
34 Temperature control valve
35 Topping control valves
36 Deaerator holding valves
37 Cascade water level control valve

HTHW Production and Storage

Whereas part of the steam reduced to 11 atm. gauge from the radiation boilers and of the live steam from the waste-heat and auxiliary boilers is fed to the direct industrial consumers and at times also to the emergency power generator set and the cold water condenser, the main flow passes through a large header into the four parallel cascade transformers and steam/HTHW transformers with a capacity of 20 Gcal/h each (Fig. 7). In these the return from the district heating system is heated from about 80-120 C to 180 C. Part of the HTHW flows into the layer-type accumulator plant consisting of four accumulators with a capacity of 100 m^3 each, while the balance is circulated by pumps feeding the consumers supplied by the district heating system.

During the summer months when the total load on the district heating system never exceeds 20% of capacity and heat is solely generated by the waste-heat boilers, an accumulator plant with a capacity of 35 Gcal/h covers sudden demands. In the evening and at night the accumulator plant is charged by heat from the garbage incineration plant, and this heat is then released during the morning hours when the demand exceeds the output of the waste-heat boilers. This combined method of operation ensures optimum utilization of the garbage incineration plant despite fluctuating demand for heat by the consumers, while at the same time it is not necessary to fire coal and oil additionally on any major scale. During the winter, on the other hand, the accumulator plant can only be used for short-term peak lopping since its capacity is insufficient to cope with heavy demands over long periods. Nevertheless, the layer-type HTHW accumulator plant (efficiency 95%) makes a substantial contribution towards rational operation of the entire heat station—indeed it is the accumulator plant which makes possible trouble-free operation of the district heating system, subject as it is to very fluctuating loads.

Control of this part of the installations follows the same considerations as were appropriate for the boiler plants, and the control equipment is connected to the same control oil supply system. Control includes seven different control cir-

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cuits: pressure control of the live steam, of the cascade transformers and the deaerator, temperature control of the LP steam and of the HTHW, level control of the cascade transformers and charge state of the accumulators.

District Heating System

HTHW heated to 180 C in the cascade transformers is fed to seven circulating pumps in the pump room (Fig. 8) and is then pumped to the various consumers at various rates through three separate lines. One line with a diameter of 150 mm supplies the Inselspital buildings, including the Lory hospitals and the Jenner children's hospital, the hourly capacity being 20 Gcal. This line is equipped with pumps having ratings of 30, 57 and 70 h.p. (capacities of 20 litres/sec and 2 x 45 litres/sec) and has been in operation since 1953; it is largely routed through a walkable tunnel and at the time of installation was adequately dimensioned for subsequent extension of the hospital, although today it is loaded 100%. The Steigerhubel schoolhouse is also connected to this line.

The second line, installed in 1961-1964 in a tunnel with access and space for subsequent additions, has a diameter of 250 mm and a capacity of some 50 Gcal/h; it leads into the town centre. In the area of the railway station spurs supply the various groups of new consumers. Buildings with a total connected load of 23.9 Gcal/h have been connected to this second line to date, so that there is still a reserve capacity of 26 Gcal/h available from this HTHW line.

Three circulating pumps with ratings of 30 h.p. and 60 litres/sec for summer operation and 2 x 175 h.p. (2 x 105 litres/sec) for winter operation are installed for this second line. One of the two large pumps operates at constant speed, while the second pump is driven by a variable-speed shunt-wound commutator motor permitting pressure and delivery rate to be varied to suit the conditions at any given time.

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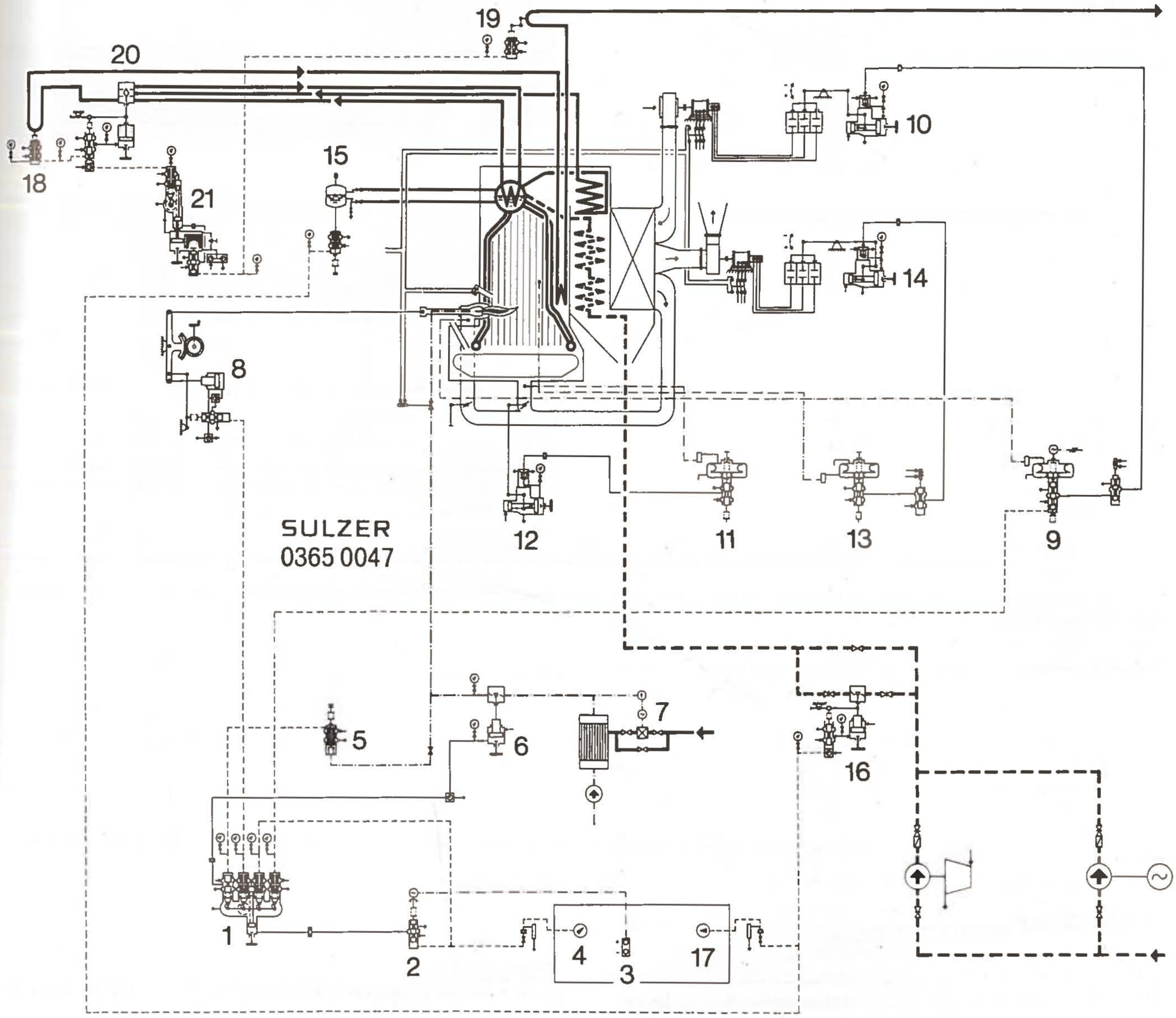

FIG. 6—Boiler control diagram.

1 Load control bloc
2 Load setting valve
3 Load adjustment knobs
4 Load indicator
5 Fuel oil pressure receiver
6 Fuel oil pressure control valve
7 Fuel oil temperature control valve
8 Burner adjustment device
9 Air pressure receiver for combustion air
10 Combustion air fan speed control
11 Air pressure receiver for grate air
12 Forced draught damper control
13 Underpressure receiver for combustion chamber
14 Induced draught fan speed control
15 Water level receiver
16 Feedwater control valve
17 Remote-reading level indicator
18 Intermediate thermostat
19 Final thermostat
20 Distribution valve for temperature control
21 Temperature control with isothermal controller

A third district heating line with a diameter of 125 mm and a capacity of 6 Gcal/h leads westwards from the station to the oil tank installation and simultaneously supplies two industrial consumers.

In addition to these three HTHW district heating lines there is also a steam line (loaded to 80-90% of capacity today) installed in 1954 for supplying steam at 6-8 atm. gauge at the rate of 8 tonnes/h or approx. 5 Gcal/h to two industrial undertakings.

The district heating system with the four lines thus has an hourly transport capacity of some 83 Gcal, of which only about half is required at the present time; a large reserve is therefore available for subsequent additions.

Thanks to good insulation by mineral wool up to 130 mm thick with metal cladding, the temperature drop in the feed lines is only about 1-2 C per kilometre under full load, while this rises to 5-8 C under low load.

Pipe installation received special attention; resting on steel balls in iron support frames, the pipes can expand freely. In the feed line expansion amounts to about 1.8 mm per running metre—or 4.5 metres over the entire length of the lines.

Wherever possible it is attempted to absorb this expansion by lateral pipe movement in the pipe bends where the direction of the line changes. In large pipe cross sections in long and straight pipe runs, special expansion loops or lateral compensators were installed as spring elements at intervals of 100 to 120 metres. These compensators, fitted with removable insulating covers to prevent heat losses, enabled the dimensions of the expansion chambers for the line leading to the area of the railway station to be kept within acceptable limits.

Shut-off valves fitted at intervals of 300 to 500 metres facilitate and accelerate any repair work and permit sections of the lines to be shut down and drained as well as enabling new connections to be made to them.

Heat Consumers

Heat supplied to the consumers by steam or HTHW is metered at the intake of the consumer sub-station, part of it then being fed directly to some consumers, but most of it is transferred to the internal plant heat system via heat transformers. The consumers are obliged to return the HTHW in a sealed circuit to the district heating system. To ensure transfer of heat with a minimum of energy for the pumps, the temperature drop should be at least 90 C under full load. Good cooling of the HTHW requires extensive arrangement in series of the consumers in the sequence of their working temperatures on the secondary side. In the first stage the laundry machinery is connected to the HTHW system, then the steam transformers for humidifying steam, sterilization equipment and kitchens, followed by the space-heating transformers and finally the hot service water generators. To ensure rational operation, these systems for the sub-stations and transformers required well-conceived electrical and electronic control systems.

To enable the thermal energy drawn by the various consumers to be invoiced, the actual consumption has to be accurately metered. Whereas mechanical meters are used for small consumers with an annual consumption equivalent to less than 10,000-15,000 SFr., the consumption of large users with a contractual consumption of more than 500,000 kcal/h is measured with the aid of electrical measuring devices which transmit the measured data to the central meter console (Fig. 8). Simultaneous display of the principal measured data for all large consumers on a single console gives the station manager a clear picture of conditions throughout the entire system at all times. Any trouble or irregularities are apparent at once. Moreover, calculation of the charges due for heat consumed is simplified, since the consumption of all the large consumers can be read off from this central measuring console.

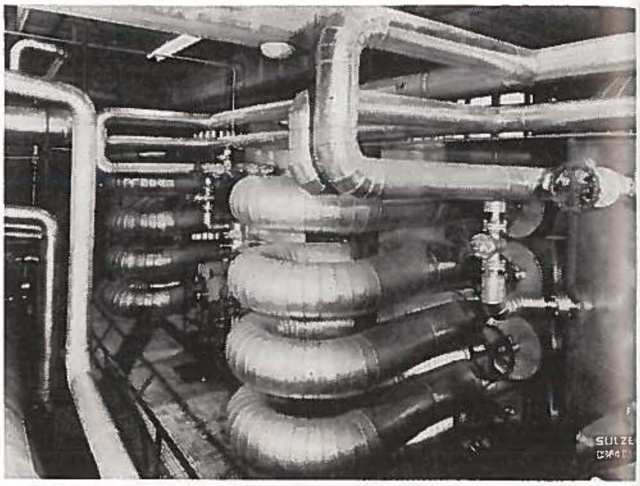

FIG. 7—Cascade transformers.

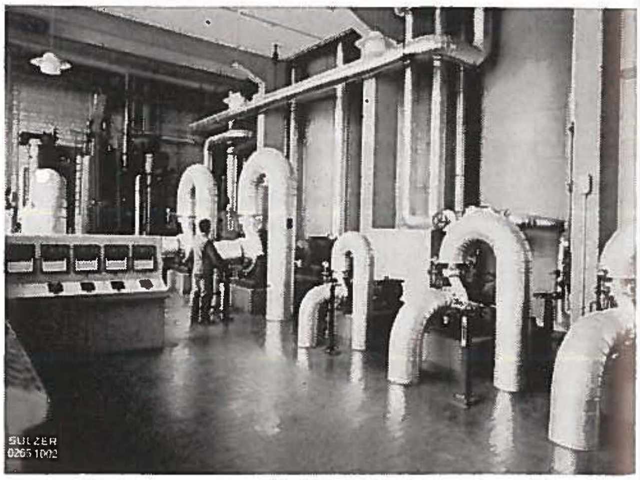

FIG. 8—Pump room with heat metering console on left.

Power Generation

Although the 35-45 million kWh that the plant has to supply to the Municipal Electricity Utility annually are insignificant compared with total Swiss power requirements, they nevertheless help to provide local peak lopping; the technical realization of this interesting combination created, from a purely garbage incineration plant, a district heating and power station which in addition to heat is also able to supply electrical energy at a cost of about 5 Swiss Centimes per kWh—in other words at very favourable rates.

Two Oerlikon alternators coupled to single-cylinder impulse steam turbines of Escher-Wyss manufacture were installed for this purpose. The available head can be used to the optimum in these machines.

The backpressure turbine with a rating of 2,400 kW at 9,500 r.p.m. consumes a maximum of 30 tonnes/h of steam at 58 atm. gauge and 465 C at the turbine inlet (11 atm. gauge and 285 C discharge). The turboalternator with a maximum rating of 3,000 kVA at 11,000 V is driven at

3,000 r.p.m. via reduction gearing. In a normal year this turboset is able to supply some 6.2 million kWh to the public supply system. The condensing steam turbine with a rating of 10,000 kW at 3,000 r.p.m. consumes 40 tonnes/h of steam, the intake and discharge pressures being 58 atm. gauge and 0.057 atm. absolute. The effective alternator output of 10,080 kW at a feedwater preheat temperature of 130 C is equivalent to a heat consumption of 2,650 kcal/kWh at a power factor of 0.8. Employed according to the given conditions during the winter months, this set can supply about 30-40 million kWh.

The condenser is arranged beneath the turbine, the exhaust steam being cooled by 2,000 m^3/h of circulated water. Heat from the condenser is dissipated to atmosphere by cooling towers arranged near the boiler house and handling some 18 million kcal/h. Make-up water required at the rate of about 150 m^3/h by these two cooling towers is supplied by a groundwater intake some 1,800 metres from the station.

Operational Results

The acceptance tests carried out by the SDVB over a period of 4 days once again demonstrated the particularly favourable characteristics of our radiation boilers for the existing conditions; during a three-hour test under normal load with oil firing an efficiency of 94% was measured. A check of the deaerating equipment showed a residual oxygen content of 0.007-0.01 mg/l in the feedwater, compared with a guarantee figure of 0.02 mg/l. A check of the purity of the steam showed a conductivity of 0.89 to 1.7 μS (microsiemens) and a silica content of 0.019 mg/l, compared with the guarantee figures of 2 and 0.02 respectively.

During the heating periods 1964/65 and 1965/66 the plant gave absolute satisfaction, although because of the new large consumers only taking part of their loads the load on the high-pressure boilers and backpressure turboset was only small. On the other hand the condensing turboset was practically under full load throughout the entire winter, so that 33 and 36 million kWh were supplied to the municipal electricity utility during these two periods. At the same time it was demonstrated that no nuisance is to be expected in the immediate or further vicinity by the exhaust gases emitted from the tall stack. ●