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D. L. GASKILL, *Secretary.*

as to its reliability, for instance, and as to its convenience with respect to other civic matters.

In the City of St. Louis we estimate that the street traffic is relieved of some 44,000 or 45,000 large truck loads of coal and ash a year. That is a significant figure, and I would say it is more so in Boston than it is in St. Louis, with its narrow streets. I think that might be true of a good many other locations. You relieve the downtown districts of heavy hauling and you have done a great thing for the city from the standpoint of the civic requirement.

The smoke situation is one that, of course, we all have with us, and whatever we can do to relieve that is going to be very much appreciated by civic-minded citizens of your community.

With respect to the reliability of the service, our plant in St. Louis has served the two largest newspapers for from 15 to 20 years. They utilize that steam service for the heating of their matrix beds and they are absolutely dependent upon it to get out their editions. In that whole period of time, not one single paper was late in getting out, they have always been out on schedule. In other words, they have always been ready to go.

President Smith: Mr. H. U. Greene, of the Cambridge Electric Light Company, will describe the Cambridge district steam system.

CAMBRIDGE DISTRICT HEATING SYSTEM†

H. U. GREENE‡

Mr. President, this is a combination paper, a collaboration between Mr. Saurwein, of Harvard University, and myself, representing the Cambridge Electric Light Company, which company supplies the university with all of their steam requirements as well as all of their electrical requirements.

The Cambridge Electric Light Company, in addition to generating electricity, serves Harvard University and several nearby manufacturing establishments with steam for heating. The heating steam leaving the plant is at a pressure of 100 lb. and a total temperature of about 388 deg. That is about 50 deg. superheat. Practically all the steam used in heating is returned as condensate. In order to supply the newly acquired

†Part of Symposium of Sales Promotion Committee, J. W. Meyer, Chairman.
‡Cambridge (Mass.) Electric Light Company.

heating load (started about a year ago), the original 200-lb. plant was revamped and modern 400-lb. equipment installed. The revamping involved consideration of a forecast heating load of 160,000 lb. hourly peak for the winter of 1929-1930, with a yearly hourly peak increase for the next few years of 20,000 lb. per hr. In ten years, it is expected that the hourly peak for the heating load will be 250,000 lb.

Steam is initially generated at the plant at two pressures, 420 lb. and 200 lb. The plant layout is such that the heating steam may be obtained by the following processes:

1. Exhaust from a back-pressure turbine operating at 400-lb. throttle pressure.

2. Steam reduced from 200 lb. through reducing valves.

3. Steam reduced from 400 lb. through reducing valves. Temperature of outgoing steam is obtained by partial desuperheating.

The 200-lb. boiler equipment consists of four B. & W. straight tube, longitudinal drum 40 hp. and two Heine straight tube, box header, 600 hp. units. These units are equipped with convection type superheaters which deliver steam at 460 deg. total temperature. Burning equipment consists of underfeed stokers with forced draft under the grate and natural draft over the fires.

The two 448-lb.-steam-generating units which were installed during the summer of 1930 consist of 1433 hp. Sterling boilders equipped with convection superheaters, economizers and water walls. These units are fired by eleven retort Westinghouse underfeed stokers with undulating link grate overfeed sections. Base-load conditions of operation and high coal cost justify installation of water walls and large economizers to permit operation of the unit at high capacity and efficiency. I might say that we are keeping down under 300 deg. stack temperature practically over the whole 24 hr.

The back-pressure unit which exhausts into the heating system is a four-valve Westinghouse turbo-generator operating at 400-lb. throttle pressure. The rated capacity of the unit is 2500 kw. at 80 per cent power factor. A generator surface air cooler permits loading up to 3200 kw. for considerable periods. The maximum quantity of steam that can be handled by the unit is 122,000 lb. per hr. That means that at high-peak loads during the winter, we have to supplement that with reducing-valve steam, steam taken through the reducing valves. A special oil-operated governor gives two types of control speed and exhaust pressure. Under normal operating conditions, the turbine is under the pressure control and the speed is controlled by the system frequency. In other words, the turbine that we have installed for this back pressure, for giving back-pressure steam, cannot be operated separately, it has to be tied in with the system; and our system over there is tied in also with the Edison Company, with frequency control in that way. And that takes care of the speed control of this unit.

The arrangement of piping and valves gives assurance of uninterrupted service. Valves reducing from 200 lb. to 100 lb. can be cut in service should the back-pressure turbine be taken out of service. In case no 200-lb. steam is available, a 400-lb. to 200-lb. reducing valve will provide 200-lb. steam which may then be reduced to 100 lb. A globe valve between the 200-lb. and 100-lb. headers and one between the 400-lb. and 200-lb. headers provide means of obtaining a steam supply by manual control should the automatic devices fail. The line on the outlet side of each reducing valve is equipped with safety valves to guard against excessive pressure in the headers.

When the steam demands are below 122,000 lb. per hr., all steam is supplied by the back-pressure turbine. The pressure is then controlled by the oil-operated exhaust pressure governor. Let me supplement that. When we get down to about 20,000 lb. of steam per hr., that is the no-load steam on the turbine, and if the average over the day is much lower than that, it pays to take the unit out. We now have that unit out, took it out a few days ago; it probably won't be used during the rest of the summer. When the load exceeds the maximum output of the turbine, the pressure drops and causes the 200-lb. to 100-lb. reducing valves to cut in. As the reducing valves are less sensitive then the oil-governor pressure control, the operators must guard against reduction of the amount of steam going through the back-pressure turbine.

The temperature of the exhaust steam from the back-pressure turbine and from the reducing valves is regulated by hand. A nozzle in the exhaust-steam main just beyond the exhaust manifold and Elliot mat desuperheaters on the outlet side of the reducing valves furnish means of getting the desired temperature. Boiler feed water is used in desuperheating.

I might say that we are considering using boiler blowdown for desuperheating, on account of the chemical analysis of the returns, and in order to take into consideration or possibly prevent trouble from the pitting of the return lines. I haven't talked that over with Mr. Saurwein yet, we will have to talk that over before we decide definitely on it.

All steam supplied to Harvard University is metered as it leaves the power plant. In order to obtain accurate metering over a widely varying load, meters of different capacities were installed on the lines supplying the main Harvard steam lines. The capacities are as follows:

Meter on 5-in. line	15,000 lb. per hr. max.
Meter on 8-in. line	60,000 lb. per hr. max.
Meter on 12-in. line	180,000 lb. per hr. max.

The lines equipped with the metering orifices are valved so that any combination or any one line can be used. Provision has been made so that the capacities of the 8-in. and 12-in. meters can be increased without great expense.

A picture of this is that we have three different size lines that connect up between our header, our 100-lb. header, and the Harvard 12-in. lines, or the header that supplies the 12-in. lines that run to Harvard. Those are of three different sizes: 5 in., 8 in., and 12 in. Each of them has a separate Bailey Meter on it, so the capacities of the lines are as I have given them to you.

As scale formations are not permitted in modern high-capacity boilers, especially those equipped with water walls, zeolite water-softening equipment of 60,000 lb. per hour make-up capacity was installed.

The return of the condensate was justified from the standpoint of the consumer and the company. The consumer is credited with the heat in the returns, the temperature of which averages 150 deg. to 170 deg. The return of condensate permits installation of lower capacity make-up treatment equipment and also affords good boiler feed water after proper deaeration. Deaeration of the returns is very essential as they are high in oxygen and contain some carbon dioxide. The question of the life of the return lines has been brought up by the consulting chemists retained by the plant. In order to determine the extent of corrosion in the returns, several sample detectors have been installed but as yet no definite data have been obtained.

This co-operative plan of heating supply for this university is advantageous to the company because it:

1. Is able to make full use of the output of the back-pressure turbine. I would like to stress that. I think that we all know that you get

fairly low-priced kilowatt hours out of back-pressure turbines, but if you can't use all the output—if a customer put it in, for instance, and his electric load factor doesn't fit in, he doesn't get full advantage of it and in a good many cases it shows an economic loss. But in our case, with our total Cambridge load and the load factor fitting in such a way that we can use the total output, we have an economical operation.

2. Is able to operate its boiler plant at high load factor and therefore obtain higher economies than with either load separately.

3. Results in more flexible operating conditions—less rapid fluctuation in steam demands.

Thank you very much.

President Smith: We thank you, Mr. Greene, for your interesting presentation. Mr. Greene's company happens to be one of the nine properties of the Associated Gas & Electric System that is selling large blocks of steam, and this 400,000,000-lb. sale to Harvard University is no small accomplishment. We all wish that we could make sales like that every day!

The next gentleman who is going to address us, Mr. G. K. Saurwein, occupies a very peculiar position. He informed me that he was hired by Harvard University to design a steam-generating plant and build a plant for them. He now finds himself in the position of a purchaser of steam, in other words, one of our customers, and also the operator of a district heating company. Mr. Saurwein of Harvard University.

DISTRICT HEATING AT HARVARD UNIVERSITY†

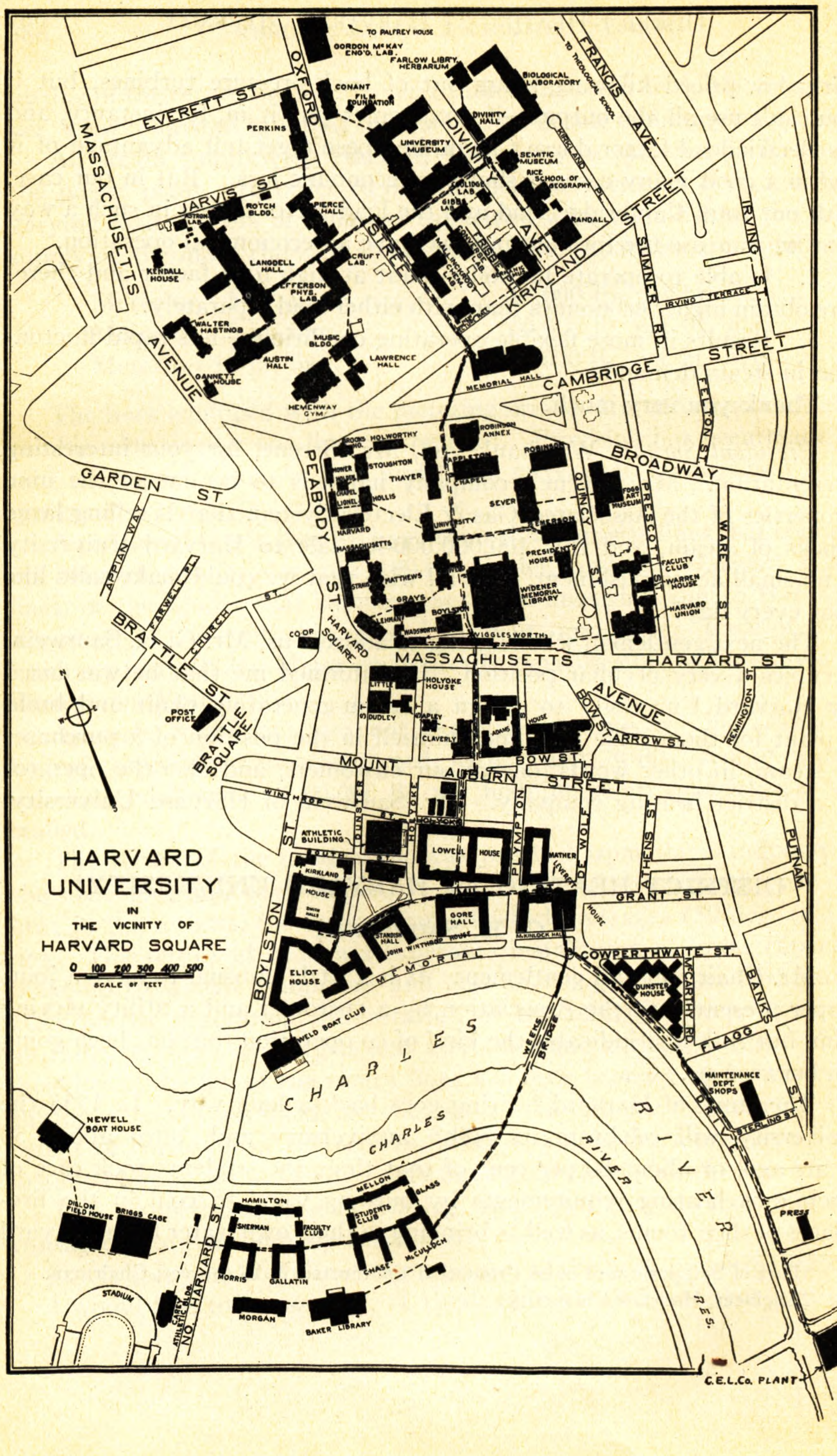
G. K. SAURWEIN‡

Mr. Chairman and gentlemen: It is a little unusual to have a joint paper presented to the Association by a customer and a utility serving him, but that just indicates the kind of co-operation that has been going on between us.

The story of Harvard heating goes back a long way. In 1935 the university will celebrate its 300th anniversary and, until about 50 years ago, or about 80 per cent of that time, the students took care of their own heating requirements by burning wood or coal in the fireplaces of their rooms, as well as bringing in their own water from the yard

†Part of Symposium of Sales Promotion Committee, J. W. Meyer, Chairman.

‡Engineer, Harvard University.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KENDALL HOUSE
WALTER HASTINGS
AUSTIN HALL
MUSIC BLDG.
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KIRKLAND HOUSE
LOWELL HOUSE
MATHER
GORE HALL
ELIOT HOUSE
STANDISH HALL
JOHN WINTHROP HOUSE
DUNSTER HOUSE
WELD BOAT CLUB
WEEKS BRIDGE
NEWELL BOAT HOUSE
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DILLON FIELD HOUSE
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STUDENTS CLUB
MORRIS
GALLATIN
CHASE
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pump. Some of the buildings are still in use, but of course they have been modernized by the addition of steam heat.

When steam heating was installed at first each building had its own system. Later on groups were tied together to a central heating plant. Then, in 1914, the construction of an extensive system of tunnels was started. There are about 110 buildings now, with a total volume of 70,000,000 cu. ft., and you can imagine that there is a wide variety of

Steam and return connections to Dunster House.

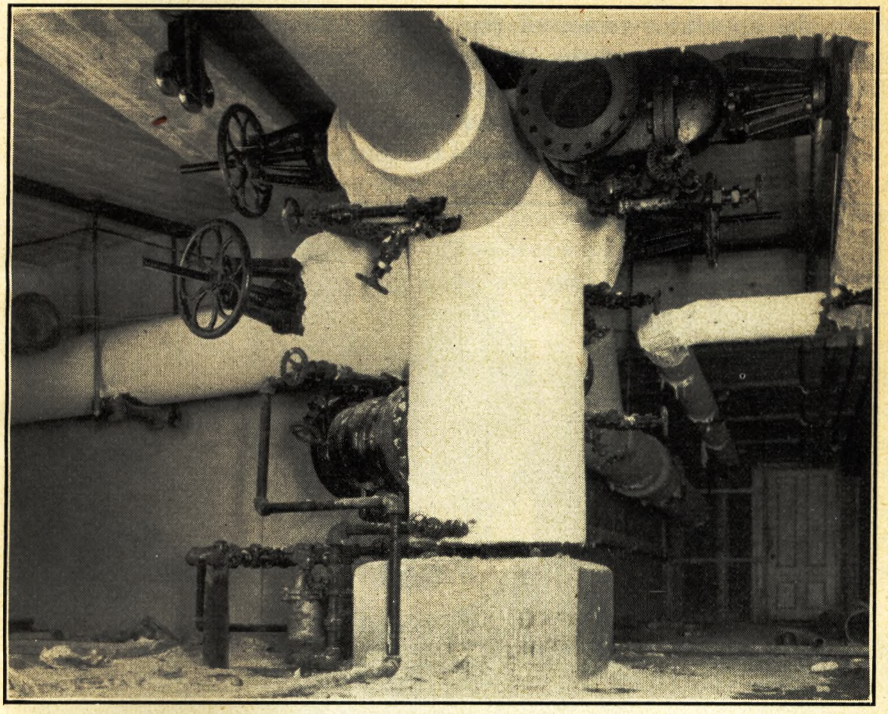
equipment. We have hot air, single-pipe steam, double-pipe steam, and a mixture of those, hot water, both forced and gravity. The hot-water system is now preferred because of the ease and simplicity of operation and the low maintenance costs. Gravity circulation is installed in the smaller buildings. In buildings of larger size, the forced circulation is used. Indirect heating, used in the dining halls, common rooms, etc., is fed with steam, the equipment being located in the basement with the converters and pumps for the direct heating, where it is easily accessible from the tunnel.

The tunnels were started about 1914, when the college was supplied with steam from the old Boston Elevated Railway Reserve Station, which was located on the Charles River Parkway. The tunnels were extended from time to time until now nearly all of the buildings contiguous to the college yard, from the Charles River north to Langdell Hall and south to the Business School and the athletic field, are connected. In 1927, 22 boilers were removed from buildings which were added to the system. When the present construction program is completed, the total connected volume will exceed 75,000,000 cu. ft.

It was practically impossible to expand the old railway plant to meet the growing needs of the college. Moreover, the site was better suited for other purposes; so the old station was abandoned. The plant has since been razed and there is a very fine building standing on the site now, Eliot House, one of the Harkness housing units.

Plans had been made for a new power plant to be located on Western Avenue on the fringe of the university development, where rail delivery of fuel was possible. This plant, however, was never built because negotiations with the Cambridge Electric Light Company, begun at about that time, resulted in a favorable contract for the supply of steam from its nearby plant. The company offered to supply steam at nearly the same cost which would result if the new university plant had been built. This, together with the fact that the corporation desires to do business with the local utilities whenever conditions are favorable, led to the decision to enter into the contract. It is a 10-year contract with 2 years' notice for change.

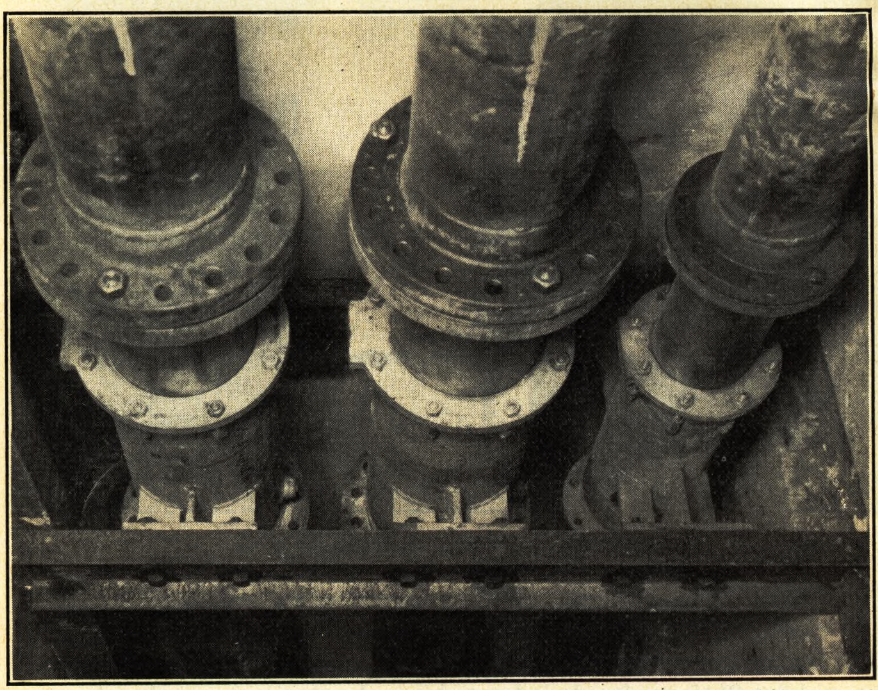
It was then necessary to build a connecting tunnel about 2000 ft. long between the steam plant and the existing tunnel system. A tunnel of approximately the same length would have been required to the proposed new plant, but not in so favorable a location. The tunnel as built runs along the Charles River Parkway, its top being a 10-ft.



Distribution header at Parkway Junction.

granolithic walk; it carries two 12-in. steam mains and one 8-in. return. Its cost, complete with all piping, lighting, ventilating, and telephone equipment, special work at seven street crossings, grading, planting, etc., was about $115 per ft. It is located in a developing area, already serving a large housing unit, with the probability of additional connections.

The main tunnels of the distribution system are 7 ft. high and, for the most part, 8 ft. wide, branch tunnels being 4 ft. to 5 ft. wide. In addition to the steam and return piping, they carry a compressed air line at 50 lb. to 60 lb. pressure for operating automatic heat-control equipment, sewage ejectors, etc.; the pressure regulators and shut-off valves are located there; the tunnel telephones and the telephone cables connecting the various buildings to the university PBX are run through the tunnels, as are also the interconnections for the electric clocks. (The electric network for supplying light and power is not in the tunnel.) Most important, the tunnels serve as passages between buildings and into the apparatus rooms of the various buildings for the operating personnel who control the heating service and attend to the heating and other equipment. This arrangement, with the tunnel phones, makes it possible to operate with a comparatively small number of men, as one man can take care of several buildings.

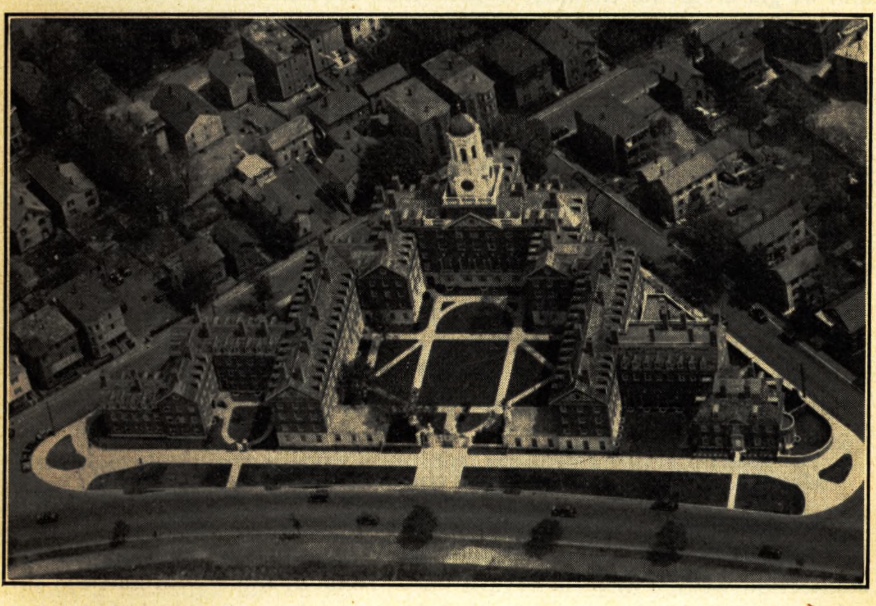


Wrought steel expansion joints in course of erection.

Steam is supplied at the plant at 100-lb. pressure and 50 deg. superheat. In moderate weather one main will serve; in severe weather both are required. Pressure-regulating valves and shut-off valves are located in the tunnel at the buildings. The steam pressure is reduced to about 5 lb. for heating. For kitchen use about 25-lb. pressure is supplied. Heat is shut off at the buildings in the evening and turned on in the morning in accordance with a schedule which varies with the use of the building and with the outdoor temperature. In zero weather the steam is kept on all night.

Over 90 per cent of the condensate is returned to the boiler plant at a temperature of 160 deg. to 180 deg. This effects a saving to the university of 10 per cent, for the cost of heat is on a B.t.u. basis. Lifting traps are largely used for returning the condensate to the return main, their exhaust being piped back into the collecting tanks. At the larger centers of collection centrifugal pumps are installed for returning the water.

Recording-integrating flow meters, steam-temperature recorders, and a V-notch condensate meter with a temperature-recording pen provide the data for the determination of the heat supplied by the plant. During the current college year about 450,000,000 lb. of steam will be used. For the purpose of distributing the charge among the departments of the university, the lifting return trap was calibrated and fitted with a counter to register the number of dumps. The approximate quantity of condensate was then calculated. The accuracy of this means of measurement depends upon the perfect seating of the check valves in the connections. Leaking check valves at these pressures, however, introduce errors of varying magnitude. In the later installations standard condensate meters have therefore been provided. For the larger users, at locations where the line pressure is fairly constant, the electric steam-



Dunster House. The new tunnel is located under the walkway along the front of this building.

flow meter is now being used. This type of meter does not register low flows: the condensate meter is really the only accurate type.

Expansion is taken up in slip joints having double anchor brackets, mounted between vertical channels. These joints and the main valves are flanged and bolted into the lines. All other pipe joints are welded. Welding elbows are used entirely. The steam lines are covered with double-thickness magnesia, the slip joints having demountable insulating sleeves; the return lines have single thickness covering. The insulation work is done thoroughly so that the heat loss is low.

The tunnels are clean, well lighted, and ventilated by means of fans, the warm air whenever possible being blown into the basements of buildings where heat is required.

The illustrations show the details of construction in the tunnels.

DISCUSSION OF HARVARD'S HEATING SYSTEM

Member: Are you penalized for the nonreturn of the condensate where you have to utilize that return line?

Mr. Saurwein: Yes, we pay for the water that we do not send back, and we get credit for the heat in the water which is returned. We return about 92 per cent.

Member: Does the return water flow by gravity?

Mr. Saurwein: The flow is by gravity down as far as Widener Library. From this point it is pumped, and there is about 15-lb. pressure in the Parkway header near the plant.

Member: Are all buildings metered separately?

Mr. Saurwein: Yes. Flow meters were installed on some of the large buildings which have kitchens, so that we could measure the total steam supplied; some of the kitchen steam, of course, being lost, but we found that at low loads, which is during the greater part of the day, the flow meter did not read at all and the flow-meter reading, instead of being more than the condensate meter was actually less. We have to guess at the kitchen losses.

Member: What can you say of corrosion in your return lines?

Mr. Saurwein: Corrosion thus far has been limited to the northern end of the system at some of the older buildings where we have an angular connection welded into the return line. Some of those 2-in. and 2½-in. connections have become pitted right near the main, probably from occluded gases which collect down there and bubble into the water.

We should be glad to get the thought of other members on that problem. Our solution is to install the connections in such a way that they can be readily renewed.

Member: What kind of metals are the returns made out of?

Mr. Saurwein: Usually wrought iron, but where we expect to renew them periodically we haven't bothered with a good class of material, but have put in ordinary steel.

It may be interesting in this connection to say that Cambridge water from the city main has been found to be very corrosive, and Alpha brass, supplied by the Chase Company, has lasted only two to three years in the service hot water systems in the buildings. So we have gone to iron pipe size copper. All renewals are in copper, all the new buildings are installed with cold and hot-water copper piping.

Is there anything further? Thank you.

President Smith: Thank you. Mr. Saurwein has given us a very interesting presentation of the Harvard System from the customer's viewpoint.

The next item on our program is an address by Harry T. Bussman, Vice-President of the Bussman Manufacturing Company of St. Louis, who will address us at this time on Sales Promotion in District Heating. Mr. Bussman.

SALES PROMOTION IN DISTRICT HEATING†

HARRY T. BUSSMAN‡

Mr. Chairman and gentlemen: With an industry that has grown as rapidly as this one has and which presents so many technical problems, I can't help but assume that great stress has been laid in your sales departments, in your sales personnel, on technically trained men; in other words, that your sales people have been and are technically trained.

In trying to think about the problem of increasing sales, it seems to me that that presents a real danger. I don't mean by that that you can get along without the technically trained man, but it seems to me that that requires that some additional training entirely outside of heating be indulged in.

Salesmanship has been defined by many sales experts as "the art of getting a man or inducing a man to want to do what he ought to do." Now, a thorough knowledge of product, such as a technically trained

†From the Report of the Sales Promotion Committee, J. W. Meyer, Chairman.
‡Vice-president, Bussman Mfg. Co., St. Louis.