extra radiators to make up for the reduced temperature due to the lower pressure. Unless the hot well is used as a storage for boiler washing, it should be discarded and an open type feed water heater used. The returns from the heating system should return into this and will then be pumped direct to the boilers without loss of heat. Steam traps which return the condensation direct to the boiler use much less steam than a pump, and should be used when all the steam from the boilers is used in the heating system, but where much cold water has to be used as feed, the pump exhaust can be used to heat it, and a pump is then as good as a trap and will usually be favored as being more easily understood. The overflow from the hot well, where such must be used, should run over a weir, where it can be seen and heard and a proper ball valve must regulate the supply of cold water, but should be placed in a little pit beside the hot well where it can be reached.

Another type of obsolete system is a two pipe vacuum system, using exhaust steam from engine or pumps, but with no traps on the radiators, and none of the refinements necessary to a good job. The back pressure on the engine is 10 or 12 lb., the pipes and coils are partly choked with oil from the exhaust steam, and as the steam is short circuiting through the nearer radiators, the more distant ones are difficult to heat.

The installation of radiator traps and some slight alteration to the piping will usually make quite a good vacuum system. The oil troubles can be prevented by means of an oil separator and the surplus steam relieved by a back pressure valve.

It is necessary to make special provision when using live steam that it shall not escape through the back pressure valve. A gate valve should be placed in the line, to isolate this valve and the feed water heater, when live steam is being used, a safety valve protecting the heating main from over pressure. This is a somewhat unusual arrangement, but is considered important.

The trouble with badly graded piping that cannot be readily changed may often be overcome by trapping it at the low points.

After an efficient vacuum system has been installed, there is a great temptation to turn the discharge from high pressure steam traps or even open drains from steam hammers into the vacuum line. This must on no account be done, as the temperature of the water leaving a high pressure line is around 100° hotter than the temperature of the vacuum line and enough water will flash into steam to kill the vacuum.

If it is necessary to install additional radiators and no vacuum traps are on hand, their returns should be kept open until such traps can be obtained.

If a remodelled system, using live steam at 25 lb. pressure exists at the far end of a low pressure vacuum system, which is often the case, and it is too costly to run a separate return back to the boiler, it may connect into the vacuum line, with a spray of cold water supplied by a ¼in. pipe to condense the steam.

One pipe heating system, supplied with steam from a distance, and discharging their returns to the sewer through a partly open valve are fairly common, and are rather difficult to handle. A continuous discharge trap of the float pattern, or better still, two connected in parallel, well protected by large sediment pockets, are the best that can be used for this service. If the system fails to heat properly with the traps in service, which is quite possible, the trouble must be looked for in badly graded piping or too small piping. This is particularly liable to happen where the risers drain back into the steam main instead of into a separate return.

The next system is one in which the exhaust steam and perhaps some live steam is discharged to the hot well, and steam driven pumps are used to circulate the hot water through pipe coils or radiators in the various buildings. A splendid system in principle, it has gained a very bad reputation through poor design and inattention to detail.

Badly proportioned piping causes short circuiting of the water and consequent unequal heating of the coils. Insufficient surface and low temperature gives inadequate heat supply.

Oil from the exhaust steam mixed with pipe scale chokes the piping badly, and corrosion, due to air liberated from a continual change of water, eats holes in the pipe in a few months.

Properly proportioned the heating is perfect. With centrifugal pumps forcing water through closed heaters, there is no trouble with oil, scale or corrosion. Piping is much smaller than with steam, the multiplicity of radiator traps is dispensed with, and all the advantages of thermal storage and control of heat at its source, as claimed for the gravity hot water system, are retained. The system is applicable to the most remote buildings, in fact it shows to greatest advantage thus and is particularly adapatable for exhaust steam. For large shops spread over considerable area, its first cost is slightly less than that of a vacuum system. In this system, as in every other, hot water supplied to wash basins and for other purposes (including boiler feeding) must be supplied by a separate system entirely.

Now let us take a typical case and see what can be saved by reconstruction along the above lines. A locomotive house of 30 stalls built many years ago, but in good condition and fairly modern as regards locomotive facilities, may nevertheless have any or all of the following defects with their corresponding preventable waste of fuel, the figures given being tons per year:—

Due to bare blower line	127
Due to obsolete steam driven compressor	163
Due to leakage of steam and loss of condensation from heating system in offices and stores	50
Due to feed water taken from hot well at a temperature of 130°, instead of heated to 210°	140
Due to badly insulated underground piping	25
Due to excessive back pressure on exhaust steam mains owing to absence of traps on locomotive house heating system	87
	592

When locomotive type boilers are used—

Waste due to lower efficiency than return tubular boilers	100
Waste due to use of steam blowers for draft where same are used continually	200
	300

Where other buildings are heated the following preventable losses occur:—

Due to loss of condensation, 25% above proper heating requirements, when boiler pressure is used, and 15% when boiler pressure is reduced to 10 lb.

Due to leakage, owing to absence of traps on radiators, 5 to 50% above proper heating requirements, probable average 10%.

The preventable loss from underground steam mains, at present buried in a wood box, without any drainings or insulation, amount to from 5 to 10 tons a year per 100 ft. of pipe.

Proposed Devices for Improving Steam Economy at Locomotive House.

Open type feed water heater.—Heating boiler feed to 210° F.

Oil separator on exhaust main.—Keep heating system at full efficiency by preventing it choking with oil and scale.

Back pressure valve on exhaust main. Regulate back pressure to minimum necessary.

Vacuum traps on pipe coils or fan coils.—Ensure even heating, full value from exhaust steam and minimum back pressure.

Magnesia or sponge felt covering on high pressure steam pipes.—Reduce condensation to a minmum and provide a durable covering, reduce corrosion.

Asbestocel covering on low pressure and heating pipes.—Assist steam circulation in heating system and provide durable covering which will prevent corrosion.

Reducing valves (properly protected by dirt traps) on live steam heating system.—Provide maximum efficiency and reduce possible loss due to radiation and leakage.

Steam traps and return pipes on live steam heating system.—Prevent loss of steam and return condensation either direct to boiler or to feed water heater according to circumstances.

Float valves, readily accessible in hot wells, and visible hot well overflow.—Prevent great loss due to hot water passing from hot wells unnoticed.

Underground steam conduit properly drained.—Prevent loss of heat due to heating the ground and melting snow.

Replace shop engine with electric motor wherever possible.—Eliminate this wasteful use of steam.

Replace present obsolete compressor with new machine, either steam or electric driven.—Old single stage compressor is inefficient as a compressor and as steam engine. Can save half of fuel it requires.

The replacement of locomotive type boilers can scarcely be justified at some points. It is doubtful whether these boilers are particularly inefficient, when provided with good chimney draft and not forced above 70 boiler h.p., that is half the power of a standard return tube boiler. When provided with poor draft, and where forced by means of steam jets, they waste enormous quantities of fuel and should be replaced as soon as possible.

Underground piping may be protected in various ways, but any really good method is very expensive and needs the most careful workmanship and supervision while being installed. For long distances with steam pipes of from 2½ in. to 10 in. and return pipes half the size, the split tile steam conduit cannot be beaten, when proper attention is paid to grading and drainage. It cannot be used under tracks, unless protected by concrete walls or cast iron pipe. For distances of less than 200 ft. a concrete trench, with double board top screwed down to cleats set into the concrete, may be used to advantage. The pipe covering should be sponge felt, or diatomaceous material; magnesia is too fragile. For piping above 10 in. or where several pipes are to be run, a tunnel should be considered. For pipes smaller than 2½ in. and distances of not more than 300 ft., it is permissible to use a wooden boxing, if the ground is dry, as the loss in heat will cost less than the interest on the cost of the more expensive construction. If the ground is wet, the pipe had better be carried overhead, or, if this is impossible, it may be cased in an outer pipe which will just fit over the covering the outer pipe being well covered with a mixture of pitch and sand.