vice of this nature must necessarily entail some increased cost of maintenance. This additional cost would be offset to a certain extent, or possibly entirely by the elimination of the damage occasionally caused by the presence of water in the cylinders, and the engines have, on the whole, proven exceedingly economical in maintenance, and it is not felt that in this respect the addition of a superheater is likely to prove at all serious.

The increase in engine failures on account of the application of a superheater was at first very small. As the number of engines in service increased, it became more serious, which led to steps being taken to remedy such trouble as developed, and during the last year or more, difficulties have been almost entirely overcome. Most of the troubles occurred through leaking at the connection of the superheater pipes to the headers. This developed on both the Schmidt and the Vaughan-Horsey types, but especially with the latter. With the Schmidt superheater, leaks would occasionally develop between the flanges into which the superheater pipes are expanded and the face of the header; if neglected, and experience showed that these leaks might easily be neglected as they did not appear to at first affect the steaming quality of the engine, the face of the header became eroded and the work of remaking the joints would be rendered difficult and expensive. This difficulty was entirely overcome by the fastening of each flange to the header by four studs in place of the clips used in the original design, and with this alteration the trouble from leakage at this point has practically disappeared. In the Vaughan-Horsey superheater, considerable trouble has occurred through the nuts getting slack, which connect the superheater pipes to the header fittings. This was found to be largely due to their not being of a sufficiently good fit, and has been overcome by better workmanship, a heavier design of nut, and the application of a simple type of lock nut which prevents any movement taking place.

Both designs of superheater are liable to one other and very annoying trouble, the occasional burning out of the return bends which connect the superheater pipes to the fire-box end. This is caused entirely by not properly maintaining the dampers which prevent the heated gases passing through the superheater tubes when steam is not being used by the engine and the superheater pipes are empty. The difficulty does not develop immediately, and if the dampers are not kept in proper operating condition, some time may elapse before any effect is shown. When the failure of a return bend occurs the superheater pipes or return bends are found to have been badly damaged by exposure to high temperature for a considerable length of time. The remedy for this class of failure is of course the proper maintenance of the dampers, and this in turn is largely affected by their proper design, so that it is important that they be arranged so as to work properly, and the possibility of their binding or becoming stuck in an open or shut position must as far as possible be avoided.

Reference has been made to various designs of superheater. The Schmidt smoke box and smoke tube superheaters used in the U.S. and Canada are of practically the same design as those which have been extensively used in Europe. The Cole superheaters are not now used, but have been superseded by a design of smoke tube superheater which has recently been developed by the American Locomotive Co., and is illustrated in figs. 40 and 41. The superheated and saturated steam headers are arranged on either side of the smoke-box and the

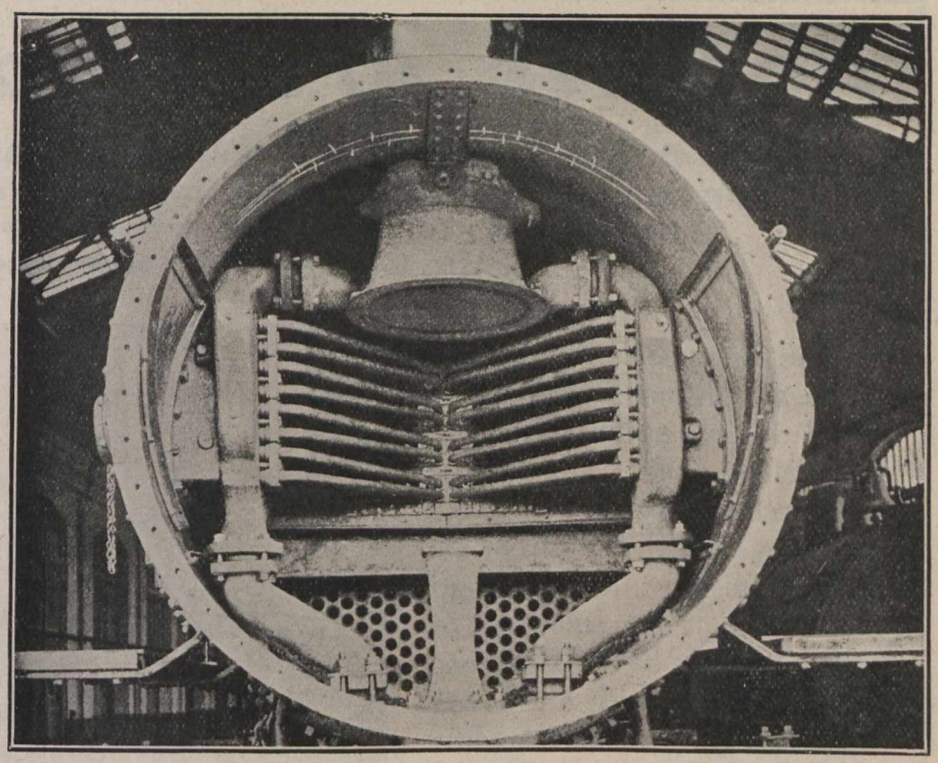

Fig. 42.

superheater pipes are bent to these headers, the connections being made by ground rings having a flat face on one side and a spherical face on the other, similar to those used for making steam pipe joints in American practice. The superheater pipes pass through a diaphragm plate in the front of the tube sheet, and small malleable iron fittings are used to fill up the spaces around the tubes and support the popes where they pass through the diaphragm plate. The arrangement of this superheater is clearly shown in the drawing, and does not call for any explanation. It has been applied, or is being applied, to 25 engines on 10 different railways and should apparently prove entirely successful, as it combines the requirements of flexibility in the superheater pipes to allow of expansion, together with ease of accessibility to the joints and superheater pipes.

The Vaughan-Horsey superheater which has been referred to, is illustrated in figs. 42 and 43. In this superheater, the headers are placed directly in front of the tube sheet, and each header is provided with a number of sub-headers. The sub-headers attached to the saturated and superheated steam headers respectively being disposed alternately in vertical rows. To each sub-header superheater pipes are connected, passing through the superheater tubes on each side of the sub-header, while the connections between the superheater pipes and the sub-headers are made by union nuts and fittings, shown in detail in fig. 44. It will be seen that these two designs of superheaters, the American Locomotive Co.'s and the Vaughan-Horsey, are in many respects similar to the Schmidt smoke tube superheater, but vary from it in the design and arrangement of the headers and superheating pipe connections.

In American practice, no advantage is gained by exposing the ends of the large superheater tubes at the smoke-box end, for the purpose of cleaning, as tubes are invariably cleaned from the fire-box end, and the chief objects desired have been found to be ease of accessibility to the joints between the superheater pipes and the headers for the purpose of inspection and tightening of joints, and the possibility of removing one element or pair of superheater pipes without disturbing any others.

With the later design of Schmidt smoke tube superheater, this can easily be effected, but with the earlier designs the removal of one element of superheater pipes from one of the top rows of superheater tubes, necessitated the removal of two or three sets of joints, and possibly loosening and disturbing others. With the short time available for repairs on engines in America, on account of the large amount of mileage they are expected to make, any device causing delays at terminals for repairs is strongly objected to. With the Vaughan-Horsey type of superheater, any pair of superheater tubes may be easily removed without disturbing others, and this advantage is also found to an almost equal extent in the American Locomotive Co.'s superheater. In both cases also, if superheater pipes are defective they can be removed and blank joints applied to the headers in their place, and the pipes replaced at the first convenient opportunity.

With the exception of the original engine referred to as having been equipped with the Schmidt smoke-box superheater all engines equipped with superheaters in the U.S. and Canada have used the ordinary type of piston packing, piston rod packing, piston valve and piston valve packing rings, commonly used in the U.S. for saturated steam. The practice varies slightly on different roads but fig. 45 shows the design of these various details used on the C.P.R., which may be accepted as fairly representative. The only detail in which any difficulty is experienced is with the packing rings in the piston. These are found to wear considerably more quickly in engines using superheated steam than in those using ordinary saturated steam, the average life in the former case being about two months against eight to ten months in the latter. It is not due to any absence of lubrication as the cylinders and pistons when examined appear to be thoroughly well lubricated and it is affected considerably by the