in order to reduce the wear and resultant replacement. Ample pin length is desirable in order to obtain lateral stability. Arrangement of motion and design of back steam chest and back cylinder covers should be such that both valve stem and piston rod packing will be easily accessible. Fillets on pins, axles, etc., should be of ample radius. Small fillets are frequently factors in failure. Where possible a piston rod of sufficient length to permit piston ring renewals without the removal of the rod from the cross head will reduce maintenance cost. Rod bolts and wedges may be dispensed with by the use of solid bushes. Rods should be designed and arranged so that it may be possible to remove them with a minimum of labor.

The C.P.R. has found that knuckle pins with a small extension on the threaded end through which a strong flat cotter can be placed have been excellent insurance against the usual consequences of loose nuts. Valves of light weight will reduce the load on all valve parts and result in reduced maintenance. Selection of high grade, close grained, cast iron for cylinder and valve bushes, piston heads and rings, and in some cases rod bushes, is more than warranted in view of the increased mileage obtainable and the corresponding decrease in maintenance. If conditions permit the consideration of heat treated, or alloy steels, unbalanced forces may be very materially reduced by the use of light reciprocating parts. The reduction of such forces will in turn tend to reduce maintenance of pins, bushings, etc.

Equalization.—Locomotives should be equalized so as to secure the most efficient guiding power from both leading and trailer trucks, or wheels. This involves the proper distribution of weight and a means of keeping the proper amounts on the various axles at all times. In general, the best results seem to be obtained by dividing the equalizing system so that the division between the front and back systems is as directly under the centre of gravity of the locomotive as wheel base and other conditions will permit. The spring gear and equalizing system should receive particular attention when being erected and also when being repaired. The tops of the driving boxes should be milled out squarely and in a plane parallel with the journal bearings. The equalizer and saddles should be fitted to their seats squarely with the pin holes so that the engine will ride squarely on her springs and track properly. The same will apply to the trailer truck equalizers and spring rigging. Trailer trucks that do not carry the back of the engine level are responsible for much avoidable tire wear.

Spring and Brake Rigging.—The application of bushes will facilitate and cheapen renewal of worn parts. Hangers and their connections should be accessible and easily removable. A driver brake main fulcrum shaft in two pieces of equal length, the outer ends supported in bushed bearings integral with the main frames and the central portion supported by a sleeve, will give more even distribution of braking power and maximum accessibility for repairs and adjustments. Brake cylinders, if at all possible, should be located vertically, in order to reduce packing wear and provide accessibility. Brake shoe heads and hangers should be so constructed and hung that shoes will swing clear of wheels when pressure is released and permit easy application of new shoes. Safety hangers should be provided to support and prevent sagging of brake rods. The ratio of brake cylinder to brake shoe pressure should be kept as low as consistent, and should not exceed commonly accepted ratios. This will insure that false travel will be kept to a minimum.

Piping. — The importance of ample clamping and provision for expansion cannot be overemphasized. Piping should be as short as possible consistent with conditions. Accessibility is of prime importance. Piping should be so located that there is no obstruction of washout plugs, arch tube covers, pads, etc. Where pipes pass through the front of the cab, provision should be made for clearance or for sleeve protection to prevent wearing or cutting. The C.P.R. has found it a decided maintenance economy to place lubricator piping from cab to cylinders, etc., in a slightly larger wrought iron pipe where the feeds pass beneath the jacket and lagging. By this means the feed pipes can be removed or applied without the necessity of removing any outside covering. Air brake and steam piping should drain properly and contain no traps in which water can accumulate and freeze. It is desirable that pipes from the sand dome be as nearly vertical as possible, the bottom ends being securely clamped in alignment with the rail.

Miscellaneous.—Ash pans should be as simple as possible, and the sides should have sufficient slope to prevent the accumulation of ash under the grates. Swing doors can be suspended so that their own weight helps to keep them closed. This results in less strain on the door operating rigging.

Easy inspection and maintenance results from placing main reservoirs in an accessible location. Where this is impossible, and drain cocks are hard to reach, an extension handle, the end of which is easily accessible, makes the reservoir easy to drain.

Removable liners on locomotive and tender truck pedestals makes it easy to take up wear and reduce pedestal renewals. To prevent rapid wear between wheel hub liner face and driving box sufficient provision for lubrication should be made.

Shoes and wedges should be so designed that wear can be easily reduced and wedges kept in their proper place with a minimum of labor. Improperly maintained shoes and wedges soon result in increased maintenance of boxes, rods, pins, etc.

Pilots made of scrap boiler flues cost less to maintain than those of wood.

All oiling points should be made as accessible as possible. Handholds or small steps, properly located, to make some oiling points accessible, will soon pay for themselves. Lubricator chokes should be placed in proper position and located as near to the cylinder, or steam chest, as possible. Proper inspection and maintenance of chokes has been found the key to many lubrication troubles. The location of the lubricator in the cab where the feeds may easily be seen and adjusted will result in better lubrication. When located close to the front of the cab, or where the light is poor, proper adjustment is exceedingly difficult.

Four pane cab side windows are easier and cheaper to maintain than those containing one large pane.

Boiler jacketing should be applied in sections so that panels can be removed with a minimum of labor.

The foregoing are but a few of the multitudinous details which merit most careful thought. But little mention has been made of the possibilities of simplified design by the use of cast steel. It is felt that with the development of the cast steel industry and the production of castings which are practically equivalent to wrought iron, locomotive construction in the future may be greatly simplified. We are today, using castings that 10 years ago would have been deemed impossible to successfully cast. For example, one-piece locomotive frames are now under consideration and will soon be in experimental service. These consist of the two main frames and all cross braces cast in one piece. This is an indication of the degree of simplification that may be obtained. The maintenance of such parts has in turn been made possible by the development of the art of electric and acetylene welding.

The foregoing are simply a few indications of the importance of design in its relation to maintenance. To mention all the points that merit attention and to discuss them in detail would be far beyond the scope of this paper. Good and far reaching results can be obtained by inviting criticism and suggestions from those directly responsible for construction and maintenance. Simplicity, correlated with efficiency, should be one of the keynotes of locomotive design. This principle, which in other words is simply good judgment, will make for that degree of efficiency which will be reflected, not only in reduced maintenance costs, but also in the increased capacity of the lomocotive plant as a whole.

The foregoing paper was read before the Canadian Railway Club in Montreal recently.

United States Wireless Telegraph Stations.

The United States Navy's new high radio station in the Hawaiian Islands, which was opened recently, is said to be the most powerful radio station in the world and is designed for direct communication with Washington and the Philippines. Exchange of messages was carried out on Sept. 20 between the radio station, Sayville, Long Island, and the Honolulu station, a distance of approximately 5,000 miles. This is said to be the world's record for long distance exchange of communication by radio, and marks a distinct advance in the radio art. The tests to date indicate that communication between Washington and the Philippines will easily be accomplished with but one relay through the Hawaiian station.

The Hawaiian station is one of a chain of high power radio stations under construction by the Navy Department. The principal stations completed to date, in this chain, are Arlington, Darien (Canal Zone), and San Diego. The remainder of the stations, at Caviet (Philippines), Guam, and Tutuila, will be completed during the next two months. The high power stations consist of three masts at each station to support the aerial, each mast being steel, self supporting. The apparatus is of the Poulsen arc type, which is standard in stations of the high power chain.

A Freight Rate Suit.—The C.P.R. is claiming through a Manitoba Court $60 for freight and other charges on a shipment of horses, from W. T. Alexander, who sent several horses to Calgary and other exhibitions west of Winnipeg, during the past season. The horses were conveyed in a palace car, and it is alleged that Mr. Alexander put some vehicles in the car also. The company claims that this raised the rate, and is suing for $60, the difference between the rate for the horses and the rate for the vehicles.