pipes, and the protection of the joints by means of asbestos packed cast iron deflectors and baffles, but which are placed so as not to prevent access for cleaning and repairs to the boiler tubes or flues.

The superheating will assist materially in producing more horse-power per pound of coal consumed, and working under ordinary conditions, an arrangement of this kind should produce an economy in connection with cross-compound engines of from five to fifteen per cent.

As lubricants are now easily obtainable with a flash point of from 780° to 790° Fahr., which will always be much higher than the mean temperature of the cylinder walls, no difficulty will be experienced in maintaining efficient lubrication through the possibility of the decomposition of the latter.

LAGGING AND JACKETING.

The coal pile represents an enormous percentage of the whole expense of operating a railroad, while but a small portion of the power it produces or can produce is utilized in actual work, and the remark that "The hand that manipulates the coal shovel reaches from the firebox to the treasury of the railroad company," is often made. It has long since been pointed out as regards the enormous loss of power that has been continually going to waste through heat radiation, and to prevent which but rather indifferent efforts have been put forth.

From the fact that the radiation from a hot body increases as the temperature rises, every attention should be given to the proper clothing of all parts of locomotive boilers and machinery that are generators and containers of high pressure, which would otherwise be exposed to the atmosphere. The rate at which the loss of heat extends will depend upon the difference in the temperature of the body emitting the heat and the surrounding atmosphere, and the condensation of steam inside of an unprotected steam pipe is dependent upon the atmosphere of the steam within, the temperature of the air without, and the velocity of the movement of that air. The metal composing the cylinders of steam engines is such a good conductor of heat that it responds instantly to the changes of temperature, and a great many efforts have been made to keep the cylinders sufficiently hot to prevent the wasteful effects of what are known as initial condensation and re-evaporation at the beginning of the return stroke. It has been demonstrated repeatedly by careful tests, and has been proven that a locomotive engine wastes more steam by cylinder condensation than does any other form of steam engine. The most successful remedy for this waste of heat has been the compounding of engines, which reduces the extremes of temperature in one cylinder. Besides the practice of compounding, a variety of other methods have been tried at other times to reduce the waste due to cylinder of condensation, one of these being steam jacketing, but little success has attended these efforts. The main difficulty with steam jacketing is owing to the fact that a proper method has not been arrived at for draining these jackets, which results in their being transformed into condensers, on account of the water of condensation being allowed to accumulate in them.

Under all the ordinary conditions, condensation is so great as to warrant a considerable expenditure for its prevention, and the most practical method for lagging cylinders and other surfaces transmitting steam is to make a design such as will locate these parts where they will be less exposed, and then make use of a good non-conducting lagging having the minimum facility for conveying heat, properly applied, which will result in as practical a means to prevent radiation as can be arrived at at the present time.

The practice still in vogue of creating an air space between the boiler, other steam sheets, and the various forms of lagging is of no advantage, from the fact that the air space so provided is not a dead air space. Air is elastic and is expanded by heat, thus becoming specifically lighter, and in that condition, it rapidly diffuses itself into the air outside of greater density, the colder air taking its place. Even when hermetically sealed, air cannot be considered as dead air, unless it is also non-circulating, and to depend upon air to prevent the escape of heat by radiation, it must be held immovable and not allowed to circulate, even in confined spaces, when there will be no transmission of heat except by the sluggish process of conduction.

In consideration of the proper material for a lagging, the proper elements are non-conductivity, efficiency, economical, ease of application, structural strength to withstand frequent removals and re-applications, freedom from corrosive acids, ability to withstand indefinitely the disintegrating effect of the action of the heat, and the vibrations and concussions incident to locomotive action.

In addition, the covering should be only of material which is non-combustible and at the same time of a porous or spongy nature, with numerous air cells or spaces which will retain air between the particles of the substance.

Of the various material used for lagging, magnesia can be considered one of the best and most practical for use in connection with locomotive service. This composition is of strict neutrality, and composed of inert mineral matter that will exert no chemical action, corrosive or otherwise, upon any metallic surface with which it may be brought in contact. It will remain unaltered under all conditions of heat and moisture which confront the coverings of modern locomotives. It has qualities of lightness, firmness, structural strength and porosity, the latter quality especially, upon which depends largely the efficiency as a non-heat-conductor; and this quality being most pronounced in magnesia, it affords the greatest resistance to the transmission of heat. It can also be molded into sectional blocks of any form and size desired for ready application and removal.

Practical tests have proven that the loss due to condensation of steam in the cylinders, steam chests, cylinder heads and in other conduits of steam about a locomotive, disregarding entirely the question of the firebox and boiler, of which the former, at least, is but partially and imperfectly protected with any kind of non-heat-conducting covering, varies from 10 to 50% of the whole amount of steam consumed. This loss of heat energy can and ought to be nearly all prevented by a complete and thorough insulation. It requires as much fuel to produce one of the deserting units of heat as it does one of the working ones, and it is a fact that the outlay required to remedy this condition, in comparison with the immense waste involved in the enormous and continual loss of power and consequent expense, is but of trivial importance. But few of the locomotives in service to-day, especially on this continent, have any part of the cylinder heads, steam chests, cylinders, or any other heat radiating surfaces protected with any kind of non-heat-conducting covering, which should be done to increase the efficiency of the engine, by at least partially protecting these parts from the almost unrestricted drain of mechanical energy through the dissipation of heat.

In this proposed locomotive, the design will be such as will locate all these steam containers where they will be, as far as practicable, the least exposed. All of the outside boiler sheets, except the smokebox and combustion chamber front, will be clothed with magnesia sectional lagging, securely jacketed and made detachable at points where periodical inspections and tests at roundhouse points will require its removal.

The cylinders and their covers, steam chests, and all other conduits and containers of steam will be lagged and jacketed in the same manner, and it is expected that the saving in radiation and condensation so effected by the additional first cost, will readily assert itself in the saving of fuel.

REDUCTION OF CYLINDER CLEARANCE.

It has been demonstrated that it is not only possible, but practicable, to reduce the cylinder clearance to as low as 2%, while in the existing type of simple cylinder locomotives the clearance averages from 5 to 10%. What effect reduced clearance will have as regards steam, and the consequent fuel consumption, will be shown from the fact that in a 20 in. x 26 in. simple cylinder the effect of saving at different points of cut-off in reducing the clearance from 10 to 2% will be from 31.5 to 2.5%. This percentage is calculated presuming that the steam which fills the clearance spaces is entirely wasted, which assumption, however, cannot be considered correct for the reason that the steam confined in the clearance spaces is not all lost, but does work during expansion, in the same proportion as the expansive action of the steam which is admitted behind the piston, in addition to what is confined in the clearance spaces.

However, the wasteful effects of the large amount of cylinder clearance in connection with locomotive engines, especially those having an arrangement of the usual type of piston valves in connection with single expansion cylinders, make it necessary that this cause for loss be given consideration.

In this locomotive a piston valve of such length as will reduce to the limit the travel of the steam from the chest to the ends of the cylinder has been arranged in connection with a steam chest located close to the high pressure cylinder. On the low pressure side, a balanced plain slide valve of a construction and adjustment which will handle promptly the large volume of steam which must pass it, has been adopted in order to reduce the clearance space to a greater extent than would be possible with a piston type of valve, which would answer for the requirements. This arrangement will provide for the least amount of clearance space practicable from the valves to the cylinders, and at the same time reduce the effect of the valve friction to the minimum, and give a proper steam distribution to the pistons.

From the fact that the excessive back pressure will be eliminated from the low pressure cylinder, due to the exhaust steam not being required to create an induced draft, and as the less the back pressure the less the percentage of clearance space required, the piston clearance can also be reduced to a minimum.

A further feature which will favor making the reduced clearance space practicable is the superheating of the steam to overcome the effect of cylinder condensation.

CROSS-COMPOUNDING.

That the use of the cross-compound type of cylinders in connection with locomotive service has passed the experimental stage is now generally conceded by all persons connected with railway mechanical departments, and it is also recognized as one of the known methods for effecting a practical reduction in locomotive fuel consumption.

The results of numerous road tests with cross-compound locomotives, and which are based on well substantiated claims of economical performance in freight service, show economies in coal and water ranging from 10 to 33%, at speeds of 45 miles and under per hour. Any increase in economy with an increase in the speed mentioned is mainly due