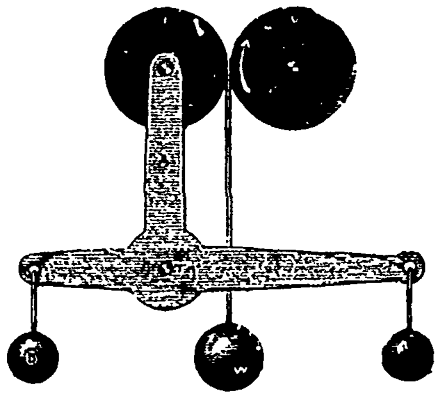
until W, was lifted. The machinery was then stopped, when the weight would descend, slipping the iron pulley upon the wood. The weight of P, was now noted; the weight

FIG. I.



was again raised, and the pressure increased sufficiently to hold the weight from slipping down, and the pressure again noted. After these experiments were made and twice repeated with the pulleys, the frame A, was reversed, so that the weight P, would tend to separate the pulleys. They were then connected by a 6-inch leather belt, and the experiments repeated, giving the results in the fourth and fifth columns.

	FRICTION PULLEYS.		BELTED PULLEYS.	
Weight raised.	Pressure required to just raise the weight.	Pressure required to raise the weight without slip.	Pressure required to raise the weight.	Pressure required to raise the weight without slip.
10	29	53	30	34
20	58	65	60	69
30	87	96	91	120
40	115	125	121	159
50	143	154	153	199
60	171	185	183	242
70	199	214	213	247
80	225	244	239	332
90	264	289	278	375
100	295	312	310	419
120	354	387	372	487
140	416	438	442	563
160	477	499	524	652
180	538	561	592	731

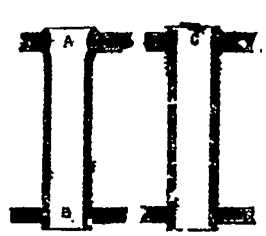
It will be seen that, in this test, the traction of the friction wheels was greater than that of the belted pulleys, and considerably more than is usually supposed to be obtained from belts upon pulleys of either wood or iron; and that while there is a marked falling off in the adhesion of the belt as the work increased, that of the friction increases as the labour becomes greater. Also that the difference in the pressure required to just do the work, and that necessary to do it without loss or slip, advances in an increasing ratio with the work of the belt; but in the friction it is almost constant throughout the whole range of experiments. The figures applied to the friction wheels are the mean results of repeated experiments; those applied to the belted pulleys are each of a single test. It is not thought that these experiments were sufficient to fully establish all that the figures show; but they were enough to prove that smooth faced wheels possess a much higher tractive power than has been generally supposed.

And now a word as to some of the advantages of friction gearing. Being always arranged with a movable shaft, so that the wheels may be thrown together or apart with the greatest ease, the machine driven by it is started and stopped at any moment, while the driving wheel remains in motion. And when stopped, the separation is complete, and may so remain for any number of minutes or months without attention, and may be again started at any moment without the least inconvenience or injury. So slight is the separation required, that it is done almost without an effort. And by it we entirely dispense with the nuisance of loose pulleys, belt shifters and idle running belts, and with the risk of throwing off and putting on belts. It obviates the delay and labour of shipping and unshipping pinions, and the rattle and bang and frequent breaking of clutches. It is durable and requires no repairs; it is compact and economises room. It does not increase the pressure on journals when the speed is quickened, as in the case with belts running with great velocity, but remains constant at all speeds. And it will transmit any amount of power, even up to 100 horse-power, with no greater percentage of loss, and with less pressure on journals than can be done by belts.

A METHOD OF FIXING TUBES IN VERTICAL BOILERS.

The following paper, descriptive of a method of fixing vertical boiler-tubes, was read before the Royal Scottish Society of Arts by Mr. R. W. Thomson, C.E., F.R.S.E., and was awarded the silver medal of the Society:—

Manufacturers and others who, on account of limited space and other reasons, use vertical boilers, have found that one of the greatest objections to them is the difficulty of keeping the tubes tight; all multitubular boilers are liable to have leaky tubes, for reasons which I will hereafter explain; but horizontal boilers do not give much trouble, as both ends of the tubes being under water, any small leaks "take up," as the deposit is forced into them. In vertical boilers, however, whenever a leak occurs at the upper end of a tube, it gets worse and worse, as no deposit can reach it, and causes great waste of fuel, and necessitates the stopping of the engine, in order to tighten the tube with a drift, or expander, or otherwise. The principal reason why tubes leak is the unequal expansion and contraction. Stays maintain the temperature of the water; but the tubes, through which alternately flame or heated air only is passing, are ever varying their temperature, and consequently their length. And this expansion follows no rule; a tongue of flame may shoot up one tube, which instantly lengthens to a much greater length than the tubes on all sides of it. This expansion and contraction being admitted, it follows that we must humour it, and still find out some means of keeping the tubes tight; and, as I have shown above, it is necessary that the upper ends, in vertical boilers, should be kept perfectly tight, it follows that the upper ends must be perfectly and firmly fixed in the top plate, whilst a certain amount of play is allowed through the lower tube-plate. This is accomplished in the most perfect way as follows:—After the boiler has been put together, the holes in the top plate and lower tube-plate, but most particularly the latter, are carefully rimed out parallel by a rimer which passes through both plates; each tube has its lower end turned in the lathe to a good tight fit in its hole in the tube-plate; the tubes are then inserted in their places, and the upper ends firmly fastened by being ex-



panded within and without the top plate, as shown in the diagram at A. The lower end is left as it is; care should be taken that it is not turned over the tube-plate in any way, but be kept perfectly cylindrical, as at B. It then acts in the same way as the piston-rod of a steam-engine working through a gland, the deposit acting as packing, which, although it may