BREAKAGE OF A THIRTY-FOOT FLYWHEEL AT THE AMOSKEAG MILLS, MANCHESTER, N. H.

Among the numerous engines of the Amoskeag Corporation, at Manchester, N. H., is a pair of 36-inch Corliss cylinders driving on to a single shaft carrying a flywheel 30 feet in diameter, 110 inches across the face, and weighing 64 tons. This wheel was belted to two jack shafts beneath the floor of the engine room, one at the cylinder end of the engine being driven by two 42-inch belts, and the other at the flywheel end driven by a 24-inch belt, running in the center of the pulley between the twin belts to the other shaft. The arrangement is shown by the diagram. This engine was used in times of high or low water, and on the 15th of October last was driving by the twin 42-inch belts mills Nos. 4 and 5, and by the 24-inch belt mills Nos. 7 and 8 and the dye house.

There was also connected to each jack shaft a water wheel, but the gate of the one on the east shaft was barely open and the other was running on four-tenths gate, not sufficient to run the machinery and line shafting in its immediate neighborhood.

Between nine and half-past on the morning of the above date, the speed in No. 5 mill ran down, as the superintendent and overseer of the carding testify, to only about one-quarter of the normal. The help, as is the custom under such circumstances, threw off the machines, and the speed started up again, but again slackened when the belts were put on. The superintendent went to the engine room and found the engine running as usual, and the engineer had noticed no trouble. Together they inspected the pulleys upon the jack shaft, and the superintendent says that the belts were slipping and the pulley hot. The engineer, remarking that he would see, turned to go upstairs, and the overseer started back to the mill through the shaft tunnel. He had hardly got away before the crash which resulted in the ruin depicted in the engraving occurred.

BURSTING OF FLYWHEEL—AMOSKEAG MILLS.

Meantime, the second-hand from the same mill had come to the engine room window on the same errand. He testifies that he looked into the engine room through the window, and saw nobody there. In a short time he heard a noise "which sounded like two heavy pieces of iron coming together. At the same time there was a sheet of fire like that from an emery-wheel from the top of the south belt shooting toward the west." He then saw the engineer coming from below, and he and his assistant ran to the throttles and began to shut the engine down. They had not left the throttles when the crash came, although the valves were found one closed tight and the other open but a fraction of a turn. The engineer was killed outright, his assistant badly injured, and the flying pieces cutting away the floor of the drawing-in room, precipitated the occupants into the pump room below, killing two girls.

The ruptured wheel was 30 feet in diameter, and ran at 61 or 62 revolutions per minute, giving a rim speed of 95·6 or 97·4 feet per second. This, although a very high rim speed, does not approach the limit at which a sound wheel may be run safe from breakage from centrifugal force. Prof. William Marks says: "The speed of rim of flywheels is in some cases pushed to about 80 feet per second, but is probably not often exceeded." We can count, however, more than twenty flywheels by the builder of the Amoskeag engines which are run at rim speeds exceeding 90 feet per second, and a 30-foot wheel by the same builder has been running at the Merchant's Mill, Fall River, Mass., for twenty-three years, whose present rim speed is 86·6 foot per second. The Amoskeag wheel was found to have spongy places in the fractured parts. Such flaws are inherent in all heavy castings, but after eight years of successful running it is hardly permissible to say that the factor of safety in this wheel was insufficient. Superintendent Manning justly says in his testimony: "These flaws were all impossible to discern without destroying the wheel. Sounding would not show them."

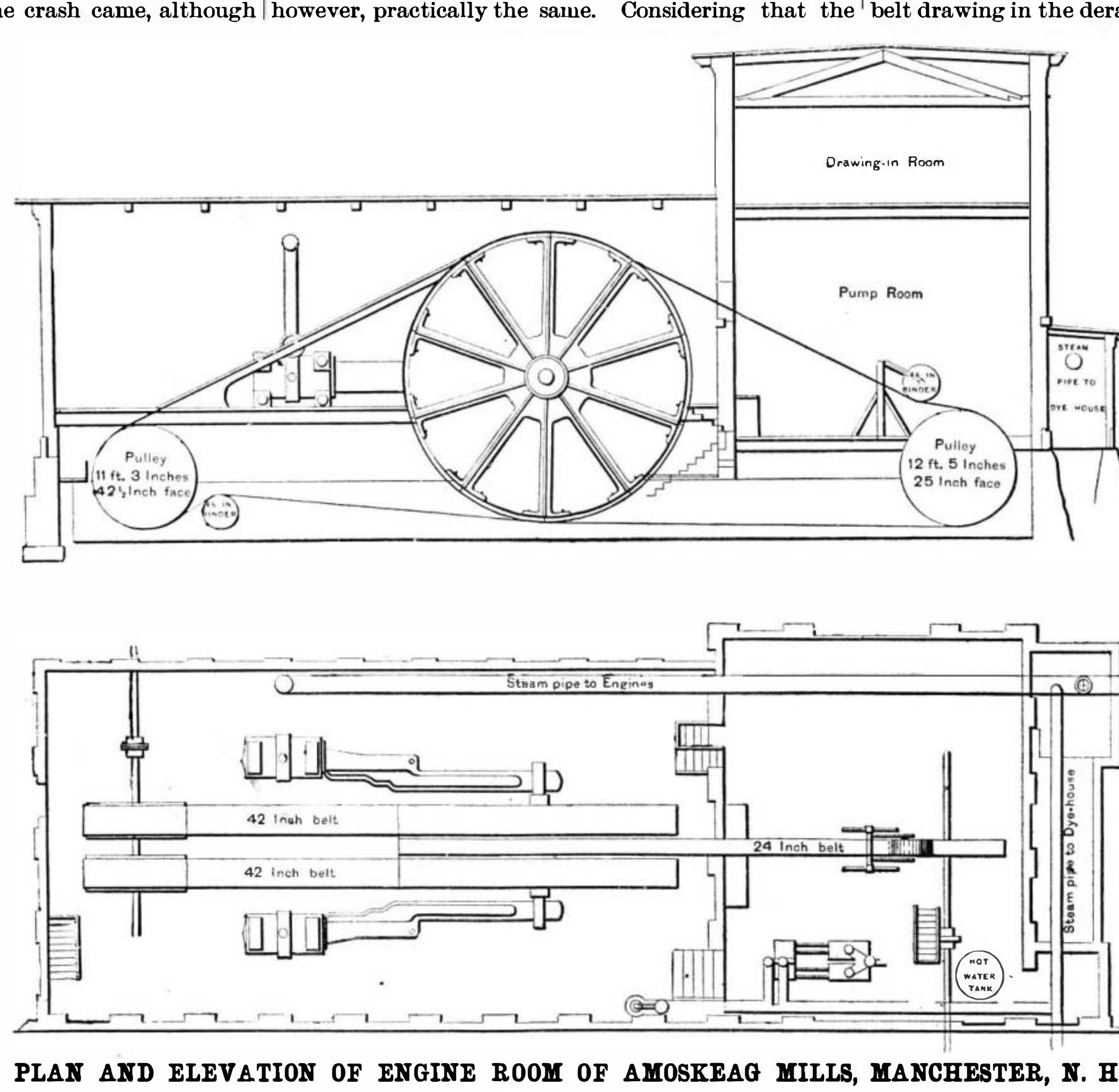
While the speed in the mills driven by the twin 42-inch belts had run down, that in Nos. 7 and 8 driven by the 24-inch belt became accelerated just before the accident. The testimony of the operatives agrees in estimating the highest speed that would have been attained by their looms at 180 picks per minute, while the normal speed was 144. This would have indicated a rotative speed for the engine flywheel of $\frac{180}{144}$ of 61 = 76¼ revolutions. From a personal inspection of the wreck and the evidence so far submitted, we fail to find anything which points to a more excessive speed than the above. The governor belt was found on, and what remained of the governor was perfectly free to act. The question comes, then, whether the wheel parted from centrifugal force at this speed or whether it was subjected to other strains which resulted in its rupture.

To consider, in the first place, the known conditions before the accident, the engine was developing the day previous 1,951 indicated horse power. Cards had been taken, but were lost in the wreckage. The load was, however, practically the same. Considering that the brake horse power was 1,890, which allows a liberal percentage for engine friction, and that this load was evenly distributed upon the belts, we should have 42 + 42 + 24 = 108 inches of belt to carry 1,890 horse power, or $\frac{1890}{108}$ = 17·5 horse power per inch width of belt. This requires the transmission of 17·5 × 33,000 = 577,500 foot pounds of power per minute. The speed of the belts at 61 revolutions was 5,749·25 feet per minute, consequently the unbalanced strain per inch of width must have been 577,500 ÷ 5,749·25, or over a hundred pounds. The normal strain for a double belt is about 70 pounds.

The proportion of the load transmitted by the twin belts to the shaft whose speed was slackened would, on the above assumption, be $\frac{84}{108}$ of 1,890 = 1,470 horse power, and it is readily apparent that belts under the degree of tension necessary to maintain anything like the above driving force could not have slipped for the length of time during which the speed was down in No. 5 mill and with the engine running at its normal rate without screeching and burning, so as to have attracted the attention of everybody about the engine house. The obvious conclusion is that the tension of the belts must have been relieved, and this naturally points to the binders beneath the jack pulleys on the east shaft.

Of the two binders, that to the south was the least damaged, though both were knocked out of position, and the north one almost completely demolished, the spokes being broken short off, and the rim, which was of wood, ground to splinters. The two idlers hung in separate journals from heavy cast iron beams, and these beams were knocked out of place and a considerable piece broken out of one of them. Of the large pulleys on the jack shaft, that nearest the end or the northern one of the pair was stripped to the hub, not a piece of a single spoke being left on. This was a split pulley, put in when the second cylinder was added to the engine. The other was made up of two narrow solid pulleys bolted together at the rims, and one half of one of the rims remained intact. The hubs of both pulleys are fast upon the shaft.

If now it had happened that the binders beneath the jack shaft to No. 5 mill became deranged, the natural consequence would have been a lessening of the tension of the belts and a running down of the speed of that shaft just as the evidence shows, and with the tension removed such slippage might have occurred with no worse local consequences than the heating noticed. If then by some means, as by the slackened belt drawing in the deranged idler or cramping its rim in some way, the jack shaft pulley was broken, its arms would be stripped by the belt as they were stripped, and the belt would have become entangled and given a monstrous wrench to the engine flywheel. The flywheel was 110 inches in width, with a single central set of arms, and the belt was on its outer edge. Such a yank might well be sufficient to produce a rupture in a rim constructed as this was. Many accessory facts point to the probability of such a sequence. The fact that one of the jack pulleys retained a portion of its circumference is evidence that it did not make a complete revolution after the general wreck had piled the *debris* about it, but that the other pulley upon the same shaft was completely stripped, shows that it must have made at least one complete revolution after it began to break. The general direction in which the pieces fell was to the northward, the direction in which such a pull would have started them. An engine whose governor is in normal condition will behave badly with a slipping belt, and



PLAN AND ELEVATION OF ENGINE ROOM OF AMOSKEAG MILLS, MANCHESTER, N. H.

the erratic action of the load with the twin belts acting as they must have done, further complicated by the water wheel, the wheel having the greater gate opening being attached to the shaft driven by the 24-inch belt, would account for the acceleration of the speed noticed in mills Nos. 7 and 8. Whether this acceleration was sufficient to have started a rupture in the rim of the engine wheel by centrifugal force, or whether the initial rupture occurred at the jack shaft, it is, however, impossible at this stage of the investigation positively to conclude.

The construction of the wheel itself will be evident from the remnants shown in the engravings. It had a single central set of 12 arms bolted into the hub in the manner shown, and to the ends of which the segments of the rim were bolted.

Of the twelve arms, two broke across the center line of the bolts in the hub, two were complete, three full length but broken at the outer end, and the rest broken across. The fragments of the rim were scattered from the river on one side to the mills across the yard at the other, and two pieces, one of which weighed 575 pounds, were thrown over upon the roof of No. 8 mill, which is at least 80 feet in height, with sufficient force to break through the heavy planking of which it is composed. The height to which a body would be projected vertically at the normal rim speed of the engine is over 140 feet. The only complete segment found was in the basement near the eastern jack shaft.—*Power.*

Rubber Foot Balls.

The game of foot ball is now of such widespread interest that much pains are taken with the ball for college use. It has an oval form, is made of the best rubber, with a pipe attachment for inflation, and is in turn incased in a stout cover, and laced. Such a ball is termed the "Rugby," and is made in one size, nine inches in diameter, and usually retails for about $4. As it is the *piece de resistance* in the contest, it is usually treasured with care when idle, although its usage is not by any means of a tender character on the field.

The ordinary foot ball comes in six sizes, respectively six, seven, eight, nine, ten and eleven inches in diameter, selling for $15 to $30 per dozen, so says *The India Rubber World.* This ball is carefully made of Para rubber and is nearly round, with a slight depression "at the poles," so to speak. The ball is made up in segments, usually six of them on the inside, there being a cloth surface, and cemented together. At the poles is a circular cap of the same material, on which the maker if so disposed can inscribe his name, or as in the case of the Hodgman Company, a handsome monogram. There is not a single stitch in these balls, and the workmanship is of such a character that when one of them is returned as defective, a black mark is made on the annual calendar of the general office of the factory. In all the years the number returned has been three in a product of thousands upon thousands of dozens.

The ball is inflated by means of a small hollow tube called a key, which fits into a cylindrical valve in the inside of the sphere. For transportation the deflated balls are packed closely in nests, taking but little room. A chief point is to get strength with light weight, great objection being made by teams to a heavy ball, which rolls sluggishly over the ground. The color of the undercase of the Rugby ball is white; the ordinary is black.

The great impetus given to the game bids fair to make this industry even more prominent than it has been in the past, and another season probably will see a much larger output than ever before.

Petroleum as Fuel in Lowell.

Accounts from Lowell state that the Tremont and Suffolk mills, Lowell, Mass., have made a practical success in using petroleum as fuel, and the estimate is made that a pound of the petroleum is equal to 1·8 pounds of coal. The mill uses the petroleum in the form of gas. The plant includes two tanks, which are buried in the ground about 30 feet from the furnaces, thus insuring safety from fire. A smaller tank is located above the larger ones and the contents of the latter are pumped into it. This small tank contains the supply for immediate consumption. A series of pipes run from here to the boilers, which are situated on a lower level.

The arrangement of the oil reservoir in relation to the boilers is perfectly safe. The level of the two large tanks is below that of the boilers, so in case the regulators fail to act and cause the tanks to burst, no serious results will follow, so far as fire is concerned. The upper tank is so small that its contents would soak into the ground before they reached the boilers, therefore no danger lurks here, even though the level of this tank is above the fires.

The oil flows from this reservoir through the pipes to the burners, under the boilers. These devices consume the oil in the form of spray mixed with steam. Perfect combustion is produced and no soot or smoke is caused, yet volumes of black smoke pour out of the chimneys surrounding the Tremont and Suffolk mills, while not the slightest trace of smoke can be seen issuing from its own. The fire is regulated by simply turning a valve. Thus it is under the immediate control of the firemen, and it is an easy matter to keep the steam at a uniform point. The mills used eight boilers before they introduced petroleum. To-day they are using but six, and yet the speed of the two powerful engines is the same and they have as much work to do as before. The neatness of the fireroom in consequence of there being no coal or ashes is an important point. The experiment has not been under way long enough to permit an estimation of the difference between the cost of oil and coal as fuel, but it is supposed that the difference is small. The oil is brought to the mills in tank cars containing from 3,500 to 6,000 gallons each.

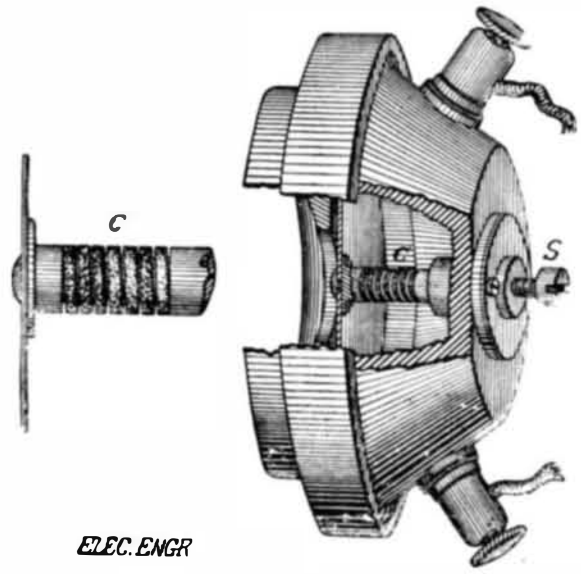
A TELEPHONE TRANSMITTER WITHOUT ELECTRODES.

BY CHAS. CUTTRISS.

While it would appear that the field of telephone transmitters had been pretty thoroughly gleaned, still among the stubble there has remained one that promises to be of considerable importance both for long and short distance transmission.

After trying numerous devices without success, it occurred to me that a helical carbon spring, if such a thing could be made, would offer the best solution.

After a few days' practice, little trouble was experienced in turning out about anything I desired. I now have the carbon helices of such resistances that when closed in their natural condition they have a resistance of about 10 ohms; but when fully distended the resistance is upward of 500 ohms, and a movement of 0·01 of an inch, tending to open the convolutions, makes a variation of from one to two hundred ohms. Their action on the instrument for which they were designed was perfect, and no sparking could be observed between the convolutions until the battery was increased to



Figs. 1 and 2.—CUTTRISS' TELEPHONE TRANSMITTER, WITHOUT ELECTRODES.

such an extent that the whole helix was heated to some 300 or 400 degrees Fahrenheit.

This absence of sparking under heavy battery at once struck me as a valuable feature in a telephone transmitter, and as the battery circuit could never, under any circumstances, be interrupted, there should be an absence of those ear-breaking kicks which are so often experienced when impatience is expressed at the distant end.

As a result I devised the simple arrangement shown in the accompanying engravings. As will be noted in Fig. 1, the helical carbon spring, C, is permanently cemented to the diaphragm and presses against the end of a screw, S, to which it is also permanently connected and by which its tension can be regulated and the convolutions of the helix brought nearer together, or separated, as desired. The carbon helix is shown enlarged in Fig. 2.

Experiments proved the correctness of my theory, and not only does the instrument transmit speech loudly, but the enunciation is so remarkably clear that I have been led to look for some particular reason why this should be so. I think it will be found to be owing to the extreme lightness of the helix (generally less than one grain); to the absolute continuity of the circuit—that is to say, the elimination of electrodes; and also to the fact as each part of the spiral is tending to open itself it absolutely precludes any tendency for the surfaces to jam or lock together.—*Electrical Engineer.*

IT is a well known fact that birds enjoy much longer terms of life than do mammals. Hesiod and Pliny both tell us of rooks that lived to the patriarchal age of 700 years, and that the average life of a raven was 240 years. How far this was correct we cannot determine. It is well known that they outlive man; while swans have been known to live 200 years, chaffinches and nightingales have been kept in confinement for 40 years. Girardin tells us that he had a heron for 52 years, and that he knew of two storks that built their nests in the same place for forty years.

Phonograph Improvements.

Mr. George H. Herrington, of Wichita, Kan., has recently patented a method of recording sound vibrations, in which the recording medium is first rendered plastic, then passed under the vibrating point or needle of the recording instrument while in such plastic condition, and finally allowed to harden, to set the impression and produce a permanent record.

He says: I employ as a recording medium to receive the needle indentations a material capable of being softened or made plastic and of afterward becoming hardened. I cause such surface to receive the indentations while in its softened or plastic condition, and it retains them when it becomes hard again. I prefer to employ a substance such as boiled tar, pitch, resin, asphalt, dental wax, or similar hard substances or compounds which become plastic when heated; and by the employment of heat I soften to the desired degree this surface as it passes under the point of the diaphragm needle, and then by cooling harden the surface to give the record permanency. The heat-affected medium is preferably applied as a coating to a suitable supporting thread, strip, or sheet of metal, fabric, paper, or rubber, and this supporting body is also preferably flexible, so as to be readily wound upon spools and passed around wheels or drums. The recording surface may also be covered with an extremely thin metallic foil or be powdered to prevent sticking to the needle or to the wheels or rollers while in a plastic condition. The heat may be applied in any suitable way, and air, water, or steam may be used, the recording medium passing through a heating chamber or over or around heating drums or rolls just before reaching the diaphragm needle. The cooling may be effected by an air or water chamber, or by drums, or by other suitable means.

The phonograph may have a motor to move the recording medium under the point of the diaphragm needle, and the same machine may, by the removal of the heating and cooling devices, be used to reproduce sound from such a record as has been described.

The same method and essentially the same apparatus can be employed for recording the movements of telephonic or telegraphic apparatus, so as to register messages sent by such instruments.

Insanity and Genius.

A good deal of comment has been excited by the publication in English of Professor Lombroso's work on "Insanity and Genius." It is a work in which the author claims that genius is the evidence of a degenerative taint, and is, in fact, an "epileptoid degenerative psychosis." We trust that our readers will not be made to feel a sense of apprehension concerning their own mental soundness by Professor Lombroso's thesis. It is one that has been worked at before by Moreau de Tours and a good many others, and neither the world in general nor the medical profession in particular has been seriously impressed by it. Men of genius have not, as a rule, been mad, except with an insanity of a scientific and scholastic kind, such as the world really needs more of. The eccentricities, monomanias, and emotional exaltations of genius have been incidental, and were not the basis of their character and temperament. Insanity is essentially a non-productive condition. No insane man has ever made a great discovery and originated great thoughts, or, by his own laborious efforts, changed the tide of human events. Insanity is a condition in which the power of adjusting one's self and one's conduct to the environment is lost. Surely there is no loss of this kind shown in the work or conduct of men of genius. Contemporaneous science has dealt somewhat kindly with Lombroso for the valuable work he has done and the new fields of study he has opened. But the *Medical Record* thinks that when he makes out Newton and Luther insane, and Christ a paranoiac, one must think that the professor himself has neither sanity nor genius.

New Use for the Telephone.

"The telephone is about to have a new application, namely, that of foretelling storms. A new discovery has been made as to one of the properties of this means of transmitting sound. By placing two iron bars at seven or eight meters distance from each other and then putting them in communication on one side by a copper wire covered with rubber and on the other side with a telephone, a storm can, it is said, be predicted at least twelve hours ahead through a dead sound heard in the receiver. According as the storm advances the sound resembles the beating of hailstones against the windows. Every flash of lightning, and of course every clap of thunder that accompanies a storm, produces a shock similar to that of a stone cast between the diaphragm and the instrument."

This paragraph, which we extract from a contemporary, is going the rounds of the papers as a fresh item of information. It is pleasing to note that the "discovery" was made as long ago as 1878, and that the SCIENTIFIC AMERICAN of that year and the following year contains several accounts of experiments in the same direction.