THE USE OF HARMONIC VIBRATIONS IN WEIGHING.

BY EDWARD MCGARVEY.

In the latter part of 1897 the writer began to experiment with certain vibratory devices in an endeavor to provide a pressure-indicator, which, when applied to weighing-scales, would afford a ready method of ascertaining the weight of an object placed on a scale, even though the beam or indicating part were removed to a distance, and a rapid and accurate means for automatically indicating and recording the weight of the cars in a moving train. The work which gave the best results was conducted along the following lines: A thin steel ribbon was suitably pivoted, the one end to a sustaining anchor-block, and the other to a scale lever or beam, in such a manner that the pressure of any object, whether it were influenced by gravity or other force, was, when acting on the lever, applied to the ribbon as tension. This ribbon was vibrated by means of the electric current. It will be readily seen that any change in the amount of pressure applied on the lever caused a corresponding difference in the fundamental rate of vibration of the ribbon, which difference varied in a certain ratio to the change in pressure.

While the method of the common pendulum and recording cylinder affords a ready and accurate means of measuring a rate of vibration when in the hands of a skilled person, it is, however, in connection with the present systems of weighing practically useless. Other means of determining from the change in the ribbon's rate of vibration the amount of force exerted upon it as tension had, therefore, to be provided. Two devices, both based upon the law of sympathetic vibration, but differing widely in details, have been developed by the writer, and accomplish the required result with a sufficient degree of accuracy.

In order better to understand the first of these methods the reader is referred to Fig. 1, in which the steel ribbon, *R*, pivoted on the supporting block, *H*, at one end, and similarly on the end of the scale-lever, *L*, at the other, is influenced by the electromagnet, *M*. At any distance from this arrangement of parts, another similar ribbon, *R'*, is placed in an inverted position, the upper end being pivoted on the scale beam, *L'*, at the point *O*. This ribbon is also influenced by an electro-magnet, *M'*. At the pivot-bearings, *H* and *H'*, are placed spring and screw contacts, *C* and *C'*, which operate to open and close the respective circuits at each vibration of the ribbons.

Two distinct circuits are used. The one through battery *B*, through magnet *M'*, and line to switch, *S*, interrupter, *C*, magnet, *M*, and ground, is the main line circuit, and serves to vibrate the ribbon, *R*, and also the ribbon *R'* when it is in unison. The other, a short local circuit from battery, *B'*, through switch, *S'*, indicator, *I*, and interrupter, *C'*, serves to show by throwing a pointer on the indicator, *I*, when the ribbon, *R'*, is in a state of vibration. The pair of ribbons, being alike in every respect, have the same natural rate of vibration when subjected to the same degree of tension. By the arrangement of the circuit containing the electromagnet, *M* and *M'*, it will be observed that the impulses of current traversing it are controlled by the vibration of the ribbon, *R*. The other ribbon, *R'*, will, therefore, receive an active motion only when subjected to precisely the same degree of tension as the ribbon *R*; for then, and then only, can it vibrate in perfect unison with the impulses in the magnet, M'.

If the rod, *D*, be supposed to connect the lever, *L*, with the scale, on the platform of which rests an object to be weighed, the procedure will be as follows: The switches, *S* and *S'*, are closed. The ribbon, *R*, immediately vibrates, emitting a low musical note, and controlling the electromagnetic impulses in the magnets, *M* and *M'*, accordingly. The ribbon, *R*, however, is subjected to the greater tension, on account of the object on the scale platform; therefore, the ribbon, *R'*, fails to respond to the impulses of the magnet, *M'*, and remains at rest.

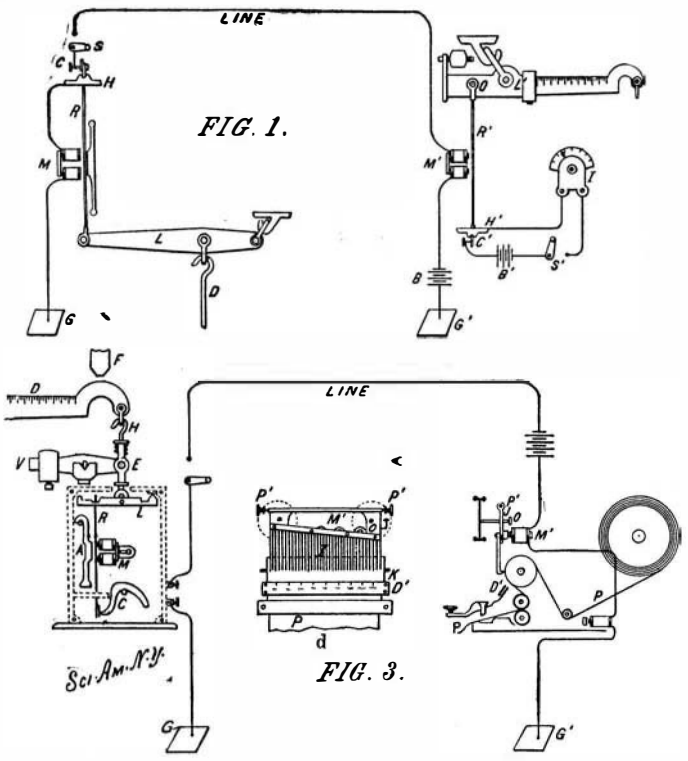


Diagram of a System of Weighing by the Use of Harmonic Vibration.

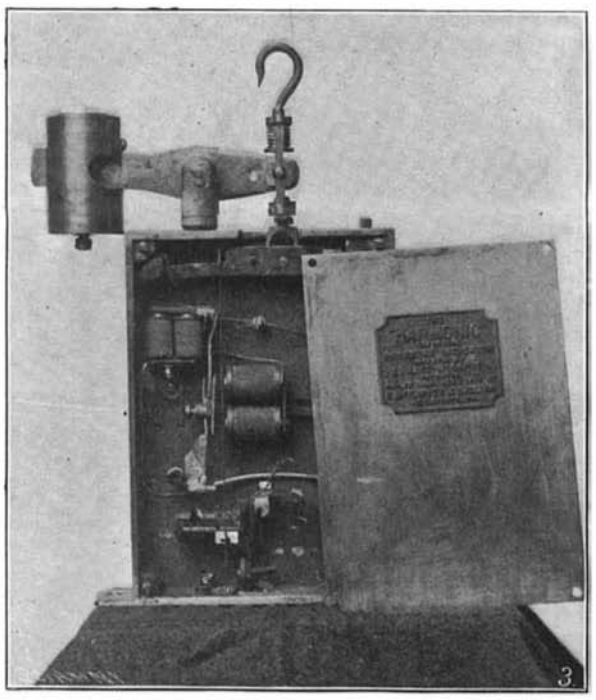
The poise on the beam, *L'*, is now moved by hand until the pointer on the dial of the indicator, *I*, falls back to the normal position, whereupon the correct weight will be indicated by the position of the poise on the beam, *L'*. The reader will understand that, as the poise was moved outward, the tension of the ribbon, *R'*, was gradually increased until both ribbons were in perfect unison, at which time the ribbon, *R'*, responded, thereby introducing resistance into the indicator circuit at the point of contact, *C'*. This fact was made known by the movement of the pointer on the dial of the current-meter, *I*.

The interrupter which first took the form of the common post and screw contact was replaced in both ribbons, by weighted hanging contact levers, the platinium tips of which rest against the springs on the ribbon-hangers. These interrupt the circuit by an inability to follow the rapid movement of the ribbons, and present the advantage of being always in adjustment, whatever be the position or vibratory rate of the ribbons.

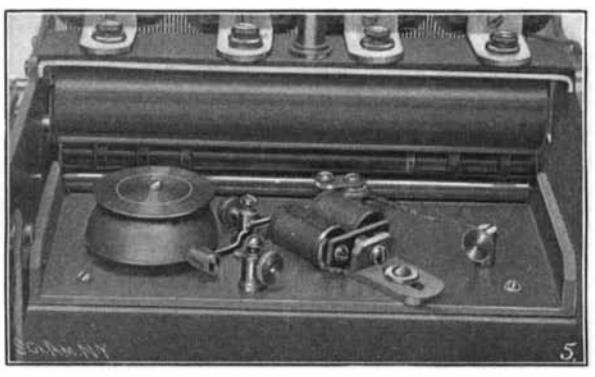
The second form of apparatus differs from the first in dispensing with the second ribbon. In its stead a series of thin reeds supported on the bar, *d*, Fig. 3, each having a different vibratory rate from the others by being slightly different in length or weight. The supporting bar is so arranged that it will be vibrated in unison with the ribbon at the scale, and the reeds are tuned in unison with the ribbon at the different degrees of tension corresponding with the force applied. Thus, when an object is placed on the scale and the circuits closed, only the reed or reeds having a rate nearest to the fundamental rate of the ribbon at that time will be vibrated. These principles form the basis of the recording indicator designed for use on the railroad track scale.

In Fig. 3 the principal working parts and circuits are shown, the metal case to the left containing the ribbon, *R*, magnet, *M*, lever, *L*, and interrupter, *C*. These parts communicate by means of the rod, *E*, and hook, *H*, with the clevis on the end of the scale beam, *D*, in such a manner that any upward pull exerted by a force acting on the beam will result in a corresponding increase in the fundamental rate of the ribbon, *R*. The extra lever, *V*, with the poise, serves to hold the ribbon and lever, *L*, in position, and also to give the proper adjustment of initial tension to the ribbon. The pendulum-like part, *A*, acts to start the vibration of the ribbon immediately when the current is switched on. Should the ribbon fail immediately to start, the steady attraction of the magnet, *M*, causes this part to strike a quick blow on the ribbon near the lower node. The vibration being started, the attraction of the magnet, *M*, becomes intermittent, whereupon the part, *A*, falls to its former position. A safety spring with proper adjusting screw is attached to the hook, *H*, which, in case the parts are overloaded, limits the tension on the ribbon by allowing the beam to rest on the post, *F*.

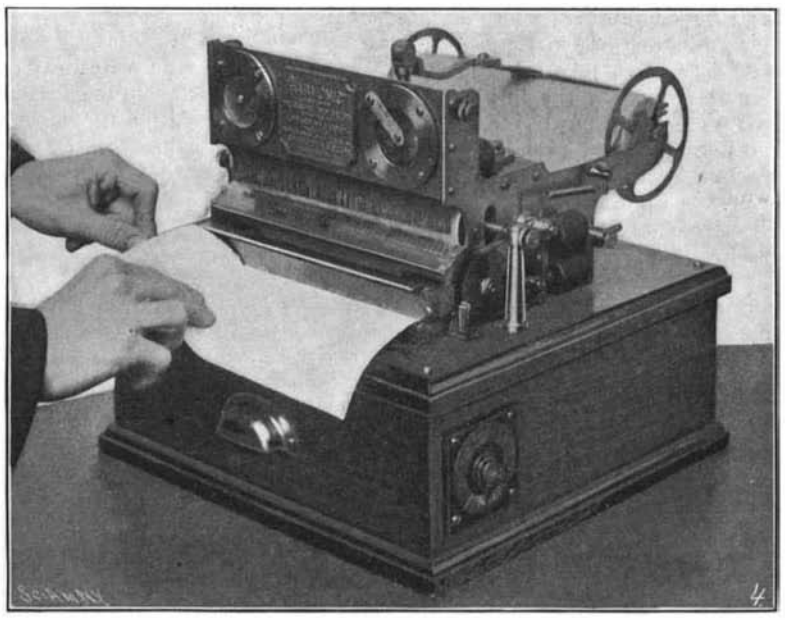
In the same figure to the right are sketches showing the main features of the recording mechanism, which are also shown in the other figures. The first sketch, a front view, *d*, shows a row of reeds, *I*, fixed to the plate, *J*. This plate, which is pivoted on the frame of the machine by trunnion-screws at *P P'*, and connected by screws at *O O* to the respective centers of two sheet-steel diaphragms, is vibrated by the electromagnets, *M*, in unison with the ribbon. Back of the reeds is placed the cylinder, *K*, over which the band of record-paper is drawn by feed-rollers operated by electromagnets. The tips of the reeds are slightly separated from the record-paper and engage with it only when actively vibrating. The reeds gradually decrease in length and increase in rate of vibration to the right. The reeds are tuned, the first one to the rate of the ribbon at its initial tension, and each succeeding one to the successive increments in rate due to a certain definite additional weight placed on the platform of the scale. As the reeds vibrate with full amplitude only when in unison with the impulses transmitted through the plate, *J*, and controlled by the ribbon, it



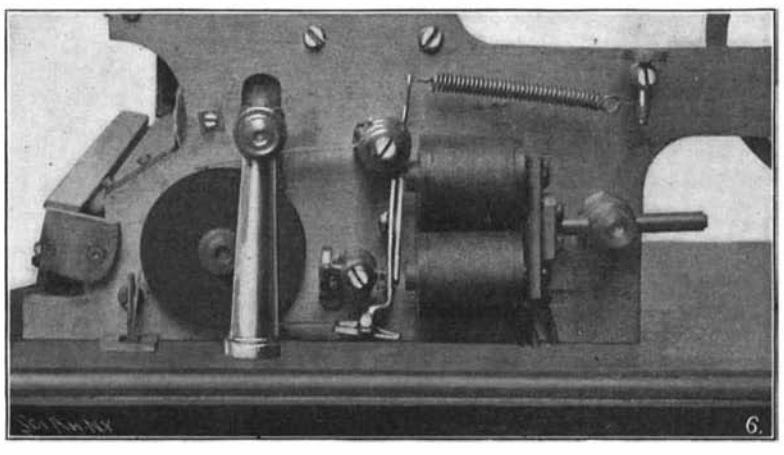
Case containing ribbon and parts.



The Back of the Recorder, with parts removed to show the Relay.



The Recorder.—Showing the manner of detaching a section of paper.



A Portion of the Driving Mechanism.

AN APPARATUS FOR WEIGHING MOVING RAILWAY CARS.

will be seen that any proper increase in the load will have the effect of throwing into motion a reed which is shorter and consequently nearer to the right of the bar. So well does this operate in practice, that by lifting on the beam with the hand, thus rapidly increasing the tension of the ribbon, the effect on the row of reeds of a wave moving from left to right is presented to the eye, so nearly instantaneously does one reed drop and the succeeding one take up the active motion. A rule, *D'*, graduated like the beam, *D*, on the scale is fixed in front of the cylinder and just below the tips of the reeds. The length of graduation is equal to the length of the row of reeds and the width of the band of paper. It serves to show in numbers the weight on the scale platform. The tips of each reed are opposite a division line.

The cylinder, *K*, which is properly insulated from the frame of the machine, is connected with a secondary terminal of an induction coil, while the frame is connected with the other terminal of the same coil.

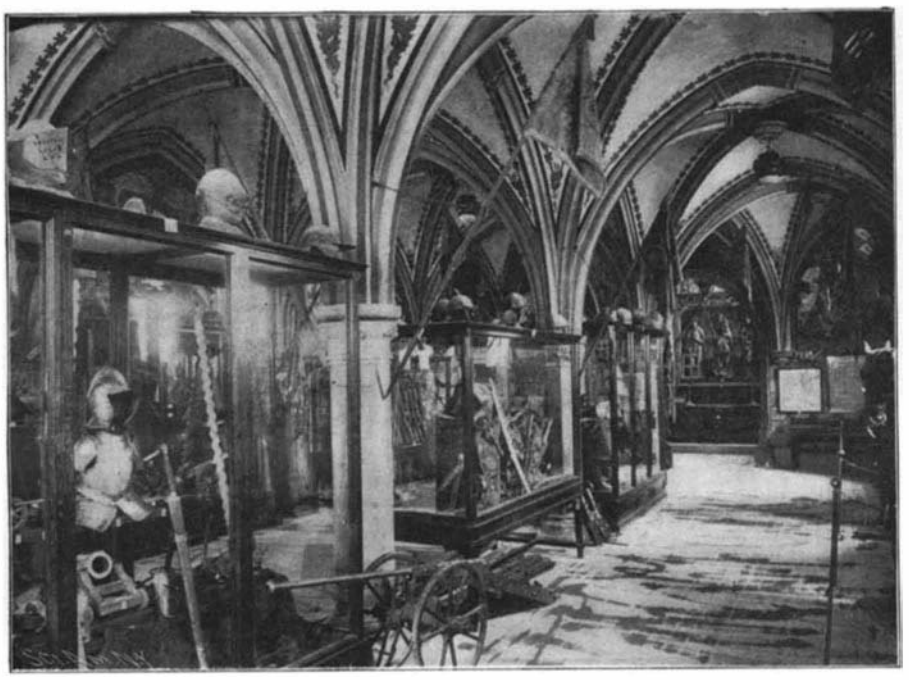
A spark gap adjustable by a screw leads the current until one of the reeds begins actively to vibrate adjacent to the cylinder, whereupon the spark following the path of the least resistance perforates the paper opposite the tip of the vibrating reed. During this time the ratchet motion has been operating to feed the paper forward. Hence, a line of perforations is burned in the paper band, the position of which line relatively to the edge of the paper indicates the weight of the car.

In the completed machine, as shown in photographs, the ratchet movement consists of two electromagnets, each of which drives an oscillating finger against a ratchet-wheel. Either of the magnets develops sufficient power to feed the paper independently of the other.

The dry cells, which operate the feed and the spark coil, are inclosed in a special box, on the front of which is arranged a series of contacts with arms for the convenient addition of new cells as required. The paper band which unwinds from a drum at the back of the machine during its perforation is fed out in front, and underneath a special rule, designed to be pressed down by a key, thereby enabling the operator readily to detach a section of the paper. Rail contacts are provided, by which the car will, when on the scale, automatically close the circuit and make the record. In the same circuit is placed a switch and key to be used by the operator. In order that the closing of a single circuit shall start all of the different movements, a special relay operated from the rail-contacts and key is placed in the base of the machine.

The arrangement of circuits in the apparatus is such that the recording mechanism may be removed to a distance to the scale, and placed for instance in a railroad company's general office, the regular telegraph line being used to conduct the impulses. The recorder will interfere in no way with the regular business of the line, nor will the operation of the regular instruments affect the accuracy of the weight records.

When a car weighing, for example, 96,000 pounds is on the scale and the contacts are closed either automatically or by hand, the ribbon immediately starts to vibrate at a rate governed by the weight of the car, thereby introducing impulses into the main-line circuit leading to the nearby or distant recorder; these impulses of current causes the plate supporting the reeds to vibrate and to transmit the motion to the row of reeds. Now, the only reed having the proper fundamental rate and, therefore, the only one to vibrate with full amplitude, is, if properly tuned, the one opposite the mark denoting 96,000 pounds on the graduated rule. As the feed motion and spark-coil were started by relay almost on the instant with the ribbon, the parts, as long as the circuit remains closed, continue to draw a line of perforations at a position on the band of paper denoting 96,000 pounds by the rule.



THE EXHIBIT OF ARMS IN THE HUNGARIAN PAVILION.

While, for the sake of clearness, mention was made of but a single reed vibrating actively, it is obvious that when the ribbon has a rate at a certain point between that of the two consecutive reeds having the nearest to the proper rate, both reeds will be vibrated with equal amplitude and make a record; and in no way will the accuracy of the record be thereby impaired, as two but slightly separated lines will be drawn, which can be correctly averaged on the rule with the eye. When this system of weighing was recently tested on an 80-ton scale owned by the Central Railroad of Pennsylvania, under the supervision of Superintendent of Motive Power, J. J. Walsh, highly satisfactory results were obtained, and the practicability and merits of the system were fully demonstrated. The tests were made with moving cars, and it was shown that less than one second of time elapses after the circuit is closed, until the ribbon and reed respond to the proper rate. From this and other practical tests, it is not too much to say that the feat of weighing a train moving even at regular transit speed over any properly constructed scales, and of simultaneously recording the weight of the successive cars, is within the capabilities of this system.

THE PAVILION OF HUNGARY—STREET OF NATIONS AT THE PARIS EXPOSITION.

PALACE OF HUNGARY AT THE EXPOSITION.

One of the most interesting of the National Buildings overlooking the Seine is that of Hungary, designed by the architects, Balint and Jambor. Its different façades represent portions of celebrated buildings; the side facing the Seine, shown in the illustration, shows the Tower of Kormocz and part of the Château de Vadja. The tower, which rises to a considerable height, spans the pavement by pointed arches, with a smaller arch in front. The middle portion has three tourelles, forming bays, which, with their connecting portions with gothic windows, give a picturesque effect. A small gothic chapel terminates this portion of the building. The sides, in the Renaissance style, are of a golden yellow, contrasting with the gray of the main façade. In the rear of the building, shown in the illustration, the portal is copied from the ancient Chapel of Gyulafehervar; a smaller Renaissance façade is seen on the left, and on the right is a massive octagonal tower, with pointed roof. The building is entered from a handsome portal; the different portions are built around a central court; the three low galleries opening into it give the effect of a cloister, with arched windows and straight or twisted columns. On one side an exterior staircase leads to the upper story. The gallery nearest the entrance is finished in polychrome decoration, in which reds and yellows predominate. At each end is an arched doorway, surrounded by reliefs and paintings. Here are reproductions of the tombs of George Apaffy XVII. and of Queen Isabella XVI. The rooms on the lower floor contain different collections of ancient arms and armor. In the first room are cases of rude looking Hunnish weapons of iron, swords, battle axes and arrow heads; the second room contains a reproduction of a sarcophagus in bronze relief from the Cathedral of Zara, and a number of ancient manuscripts and documents, besides a richly decorated saddle, battle axes and swords, the latter of the twelfth century. The illustration shows the main hall, which corresponds to the portion next the Seine; it has the form of a crypt, terminated by the chapel, with rich stained glass windows; the main portion is decorated with polychrome designs and by frescoes representing battle scenes, flags, suits of armor and cases of ancient arms.

In the central case is the saddle of Prince Bethlen, seventeenth century, richly embroidered in red and cloth of gold, and a number of ornamented sabers, one of which, seen in front, has a gold scabbard in relief designs. Saddles, guns with carved or inlaid ivory, armor casques, etc., are seen; among the latter is the pointed casque of Nicolas Zrinyi, sixteenth century, and the battle-hat of the Archbishop Fomory de Kalocsa, of leather with steel bands; also the saber of Mathias Corvin, king in the fifteenth century. Another illustration shows a collection of ancient fishing and shepherds"