THE CONSTRUCTION OF A MAGNETIC DETECTOR.

BY EDWARD G. GAGE.

The researches of Joseph Henry brought out the fact that the discharge of a Leyden jar through a coil of wire surrounding a needle produces an effect quite unlike that of a voltaic current. Instead of being uniformly magnetized, the needle is seldom magnetized twice alike throughout its length, and its poles are often reversed.

Although Henry rightly guessed the true cause of this irregular magnetization, namely, that the discharge is oscillatory, the principle was not applied by him in detecting oscillations at a distance, but Rutherford, some fifty years later, utilized this principle in his detector of electric waves.

A small magnetometer was placed near one end of the needle, previously magnetized to saturation, and the changes in magnetism caused by oscillations from the distant oscillator passing through the coil surrounding the needle were noted by the deflections of the magnetometer.

This apparatus was, of course, suitable for experiments only, in that a freshly magnetized needle was required after every discharge of the oscillator.

Marconi overcame this difficulty by supplying a constant source of variable magnetism in the shape of a permanent magnet, which, being slowly revolved by clockwork with its poles facing the coil of wire, supplied fresh magnetism to the core, which instead of a needle was now a bundle of thin iron wires.* As a further improvement Marconi discarded the magnetometer for noting the passage of oscillations, and in its place wound a second coil of fine wire over the first, which picked up the induced currents, and led them to a telephone receiver in which a click could be heard for every spark discharge of the transmitter.

Even this form of detector had its drawbacks, as the signals received were constantly varying, being strongest upon the approach of the magnet poles to the core, and weaker when receding, making it unsuitable for practical work. Again Marconi has overcome the difficulty by arranging the detector in the manner later described.

Although the operation of the magnetic detector is commonly called one of hysteresis, in which the magnetism of the core lags behind the magnetizing force of the permanent magnet, and is suddenly set free by the passage of oscillations through the primary coil surrounding it, the true operation, like that of the electrolytic detector, is disputed by several investigators.

It is sufficient, however, for practical needs to accept the hysteresis theory, and to so proportion the windings, core, magnet, etc., that they shall be best suited to a happy medium of wave lengths, telephone receivers, and signal strengths.

This has been accomplished in the modern commercial detector, which is due to Marconi, and is wonderfully constant, "fool-proof," and ranks next to the barretter or electrolytic detector in sensitiveness.†

Directions for making a home-made detector of this character are as follows:

A suitable baseboard for the instrument is first selected from straight-grained pine, 18 inches long, 6 inches wide, and ⅞ inch thick.

Procure the works from an ordinary clock, preferably of the eight-day variety, although those from an ordinary alarm clock will be chosen here for the sake of simplicity. Remove the balance wheel and all unnecessary dogs, screws, etc. To one end of the spindle of the last cogwheel solder a narrow strip of tin 1 inch long and ⅛ inch in width, to serve as a dog to hold a wind-brake, this to cause the wheels to revolve slowly and quietly. The tin strip should have a small hole punched through the center and placed over the end of the spindle, which projects a trifle from the under frame. A small drop of solder will secure it, after which any form of small cloth or paper vane may be attached by a wire loop or frame. Owing to the difference in construction of various clockworks, it is difficult to specify any shape or position of the brake, but the one shown in Fig. 11 gives the general idea. Cloth over a frame is preferable to paper or cardboard, as it moves silently. Allowance should be made for the movement of the vane, either by cutting away the wood around it, or projecting the vane through a hole in the base, and supporting the whole instrument on a superficial base by means of cleats. The spindle to which the hands are attached serves for the driving shaft, and should be soldered to the cogwheel through which it passes, as ordinarily it is held by the friction of a spring pressing against it.

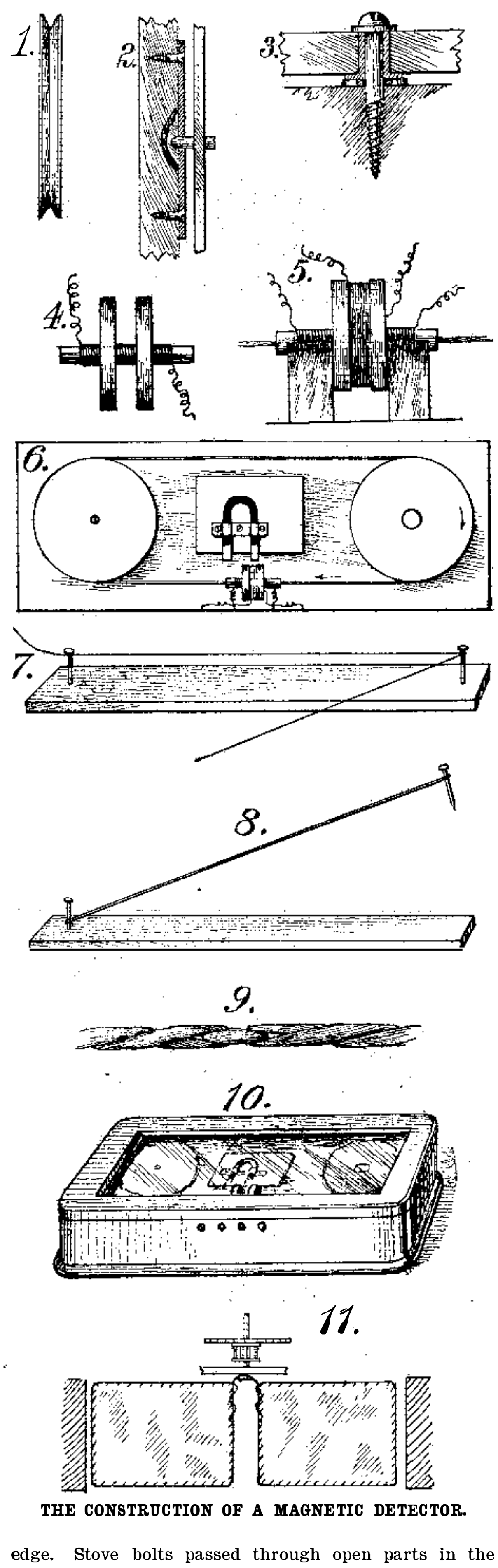
Two wooden disks, preferably birch, are now cut out 4 inches in diameter and ⅜ inch thick. Upon the periphery of each disk is cut a groove of the shape shown in Fig. 1.

* See paper by Marconi before Royal Inst. of Great Britain, June 13, 1903, in Electrician June 27, 1903, p. 388.

† The recent introduction of the compound of silicon and carbon as a detector of electric waves, and also a modified form of Fleming's rectifier used for the same purpose, renders this statement liable to error.

From a piece of heavy sheet brass cut a square 2 x 2 inches and drill a ⅛-inch hole in each corner and one in the center to fit the driving spindle on the clockwork. Place in position on the spindle and fasten with solder, being careful to keep it true. Hollow out the center of one of the wooden disks sufficiently to contain the lump of solder so formed, and fasten it to the brass square by means of small steel screws passed through the hole in each corner (Fig. 2). A small magnetic screw driver will be found very useful for passing the screws into place through the open work of the clock frame.

The clockwork is now mounted on one end of the board, the center of the disk being 3 inches from the



THE CONSTRUCTION OF A MAGNETIC DETECTOR.

edge. Stove bolts passed through open parts in the frame from the bottom of the baseboard and fitted with nuts and washers will be found the best method of doing this. A hole should be bored in the baseboard immediately beneath the winding stem, to allow for the insertion of the key. Next cut a block of soft wood 5 inches square and of a thickness 1/16 inch less than the distance between the top of the baseboard and the under side of the mounted disk. The remaining disk is now fitted with a brass bushing and a 1-inch round-head brass screw selected to fit the hole in the bushing nicely, and passed through it into the block of wood just mentioned, placing a washer beneath the disk and one under the screw head (Fig. 3). Fasten the block to the baseboard in a position so that the distance between centers of the disk shall be 12 inches.

This finishes the framework, and the coils should now be wound and adjusted. Obtain a piece of annealed glass tubing, as thin as possible, 2 inches long and ¼ inch external diameter. Hold the ends in a Bunsen flame just long enough to smooth the rough portions, flaring one end slightly with a small stick of wood. This prevents chafing of the iron rope.

In winding the primary coil over this tube it is a good plan to tie the ends tightly with thread, to prevent slipping. The wire used should be No. 36 silk-covered, and should measure 10 feet in length. It is wound in a single layer as closely and evenly as possible, leaving 6 inches of the wire at each end for connecting. The coil when wound should occupy a space of 1½ inches in the center of the tube. Give the whole a good coat of shellac and allow to dry.

Over the coil and tube so formed are slipped two small disks of ¼-inch soft wood 1½ inches in diameter (Fig. 4). The hole in the center of the disks should be just large enough to fit over the coil tightly, and shellac used to hold them in place. They should occupy a position in the center of the tube, being set ⅜ inch apart. When they have become firmly fastened in place the space between them is wound full of No. 36 silk-covered wire, leaving free ends about a foot long for connecting (Fig. 5).

Tube and coils are now placed in position on the baseboard so that the interior of the tube is in line with the grooves on the periphery of the disks, and the coils midway between them (Fig. 6). Support the tube on a pair of blocks, as shown, using a liberal amount of shellac to hold it in place.

Cut out another wooden block 4 inches long, 2 inches wide, and of about the same height as those supporting the tube. Fix this block lengthwise in the center of the baseboard. Procure a small permanent magnet of the horseshoe variety, and mount it on the block in such a position that its north pole will be pointing directly in front of and nearly touching the outside turns of the secondary coil (Fig. 6), while its south pole will be opposite one end of the tube. If the disk on the clockwork revolves from right to left (as it ought), the south pole should be to the left of the center of the tube and coils; if in the opposite direction, to the right. It is immaterial which pole is in front of the secondary coil, as long as the remaining pole is in the proper relation to the direction of the moving band, about to be described. The commercial instrument is fitted with two magnets, like poles adjoining, and facing the center of the secondary coil, but the difference in effectiveness of this arrangement is so slight as to be unnoticeable.

We now come to the last, and if not properly made, the most difficult and exasperating part of the detector, the moving band or rope of iron wire. To the uninitiated this has always been a source of great difficulty and annoyance, and though simplicity itself when made in the following manner, attempts at other methods are almost sure to result in a bungling, tangled mass of stray loops and ends.

The wire of which the band is made is No. 36 silk-covered, iron wire. Select a soft pine board ⅞ inch thick about 3 feet long and 4 inches or 5 inches wide. Drive two nails to a depth of ½ inch in the board at a distance apart equaling twice the circumference of the oval formed by the two wooden disks, when measured by a string passed around the grooves. Starting at one nail (Fig. 7) wind the wire from one to the other, always winding in one direction; that is, so as to inclose the two nails in a narrow coil of wire. When the total number of strands equals 100 the ends are connected, and one nail is cautiously withdrawn from the board, keeping the wire still on it, and drawn taut (Fig. 8). Twist the strands into a rope, keeping them taut, and remove the remaining nail from the board. Both nails are now removed from the ends of the band, being careful not to disturb the loops formed by them. Thread the band through the glass tube, passing it around both pulleys and bringing the ends together between them. The two ends are linked together by threading a separate piece of the iron wire through and through them (Fig. 9), drawing tight after each threading, and connecting the ends of the wire by tying or twisting, as in the case of the band.

This completes the working parts of the detector, and any casing may be fitted to it and finished according to the ideas of the operator.

A good casing is made by fitting the sides and ends with ⅜-inch hardwood strips extending ½ inch above the surface of the disks. This forms a box with the top open, and a nice-looking instrument is made by attaching a glass door by hinges to cover it and protect the working parts from dust and injury (Fig. 10).

The ends of the primary coil are brought to binding posts in the side of the box nearest them, and those of the secondary connected to another pair of binding posts, one on each side of the first two. If desired, a false bottom of pressboard can be fitted beneath the disks, leaving only the coils and tube, magnet, band, and disks visible.

It will be noticed in the case herein cited that the winding stem is situated in the base of the instrument—a great inconvenience that can be remedied only by gears or ratchets; but this is hardly worth while, in view of the great advantage to be gained by using an eight-day clock, which, in addition to its ability for long running, usually has the winding stem on its face. The proper speed of the driving disk is that which will cause the moving band to complete the circuit through the tube in about two minutes.

Aerial and ground are connected to the terminals of the primary coil, and the telephone to those of the secondary. An almost inaudible hissing sound, in the telephone, as the band slowly threads its way through the tube and around the pulleys, shows the detector to be in working order.

A CONTINUOUS VARIABLE-SPEED SYSTEM OF RAPID TRANSIT.

Most of the transit evils from which every crowded city suffers are due to the periodic character of the train service. The steady current of people that pours into the station must be periodically checked to await the arrival of the trains. It is this intermittent damming of the human stream that produces the rush-hour crush, and retards, as well, the unloading and loading of the cars. The only remedy possible under the periodic transit systems is to reduce the headway of the trains so as to carry off the crowds at more frequent intervals. But the headway cannot be cut down below a certain minimum determined by the length of time required to load and unload the cars, plus a constant allowed for starting and stopping. This minimum has already been reached by the New York Subway express service where, at certain hours, three and four trains are sometimes stalled waiting their turn to enter a station.

Realizing that we have reached the limit of possibilities of an intermittent or periodic service, the next logical step would seem to be in the direction of a continuous transit system. Several such systems have been proposed. The moving platform, consisting of three endless platforms traveling side by side at rates of three, six, and nine miles per hour respectively, is familiar to our readers. Another, and a most unique plan which was recently described in these columns, consists in an endless chain of cars traveling at a speed of, say, 20 miles an hour, and to which access is had by means of a large whirling platform with a peripheral speed equal to that of the chain of cars, but with a speed so reduced near the center where the station entrance is placed that the platform can be here readily boarded.

Still another continuous scheme has just been brought to our attention which is decidedly novel in many respects. It is the invention of two engineers of this city, Messrs. B. R. Adkins and W. Y. Lewis. In this system a series of short cars are used, which travel at high speed between stations, but slow up while passing a station platform to permit the passengers to alight or step aboard. In this respect the system resembles that of separate trains. However, the cars do not stop at the station, but come together to form a continuous train or moving platform traveling at a rate of three miles per hour. Once the station is passed the speed is uniformly accelerated up to say 21 miles per hour, hence the cars successively break away from the close formation and are strung out all along the line until the next station is approached, when they again draw together and pass the station as a continuous train. In other words, the cars run under a headway much smaller than the present minimum because they do not stop at stations, but merely slow up. Furthermore, this retardation is of known duration, whereas in the ordinary periodic system it is a very uncertain quantity depending upon the size and compactness of the crowd which desires to get on and off.

The method of driving the cars at this variable rate is very simple. On each side of the track, extending along the entire length of the line, is a pair of screws, or rather shafts, in each of which a spiral groove is cut. One of these is formed with a right-hand spiral and the other with a left-hand spiral. These opposed spiral grooves receive the opposite ends of the forward axle of each car, so that when the shafts are turned in opposite directions they feed or "screw" the cars forward. The desired acceleration or retardation of the cars is produced by varying the pitch of the grooves.

We are accustomed to think of screw and nut gear as adapted only for very powerful but slow motion, and it may at first sight seem to be impracticable to obtain a high speed without considerable friction, also impossible to obtain such a variation in feed as between three and twenty-one miles per hour on the same screw. However, this detail has been quite carefully worked out. The inventors propose to use a shaft 18 inches in diameter. At the slow-speed points the groove would have a pitch of 7.5 inches, while at high-speed points the distance between threads would be 52.5 inches, and the maximum speed of travel stated could then be obtained by driving the shafts at 422 revolutions per minute. The angle of the groove with the axis of the screw at maximum and minimum pitch is 45 deg. 20 min. and 8 deg. 15 min., respectively, while the screw efficiency is 96 per cent and 86 per cent, respectively, because the friction is almost entirely eliminated by using ball-bearing rollers on the axles to engage the spiral groove, and the shafts are carried in the well-known "anti-friction" roller bearings.

The screws or driving shafts are supported at frequent intervals on rollers, as shown in one of the figures of our front-page illustration. They are driven by electric motors at various points along the line, say one-fourth of a mile apart. Each motor drives a short power shaft which passes under the track at right angles thereto. By means of bevel gears the power is transmitted to a pair of short drive shafts parallel with the screw shafts. The drive shafts are fitted with broad-faced spur gears which mesh with toothed collars secured on the screw shafts. As is clearly shown in our illustration, the spiral groove passes right through the gear collars. The shaft is made in short lengths of, say, 25 feet, which are spliced together with a lap joint. An axial play of one-sixteenth of an inch is allowed at each joint for expansion and contraction. At suitable points along the line thrust collars are secured to the shaft and these are engaged by rollers which take up the end thrust.

It is the plan of the inventors to inclose the screws on each side throughout the length of the lines, providing a platform level with the car floors, so that in case of stoppage the passengers can leave the cars and walk along the platform to the nearest station. The rails are supported on a concrete bed, which is molded to form a deep trough or open conduit in which workmen can walk while cars pass over them. Should a passenger fall between the cars the latter would pass over him without doing him any injury; also, if a parcel should be dropped from the cars it would fall into the conduit without obstructing the track.

The cars are short, four-wheeled vehicles with two seats placed back to back. They are open at the sides and closed at the front and rear by means of wire screens. At stations a platform may be built on both sides of the track, so that passengers may enter or alight from either side of the car.

A system of this sort is, of course, unsuitable for any but a straight track because the shafts cannot be bent around curves. Yet the inventors propose to negotiate slight curves by laying straight lengths of shafting on chords of the curve and gearing these chords together. The cars may be carried past joints in the chords by their momentum, or by a clutch device which will act automatically. Some such scheme would also be necessary on a straight line to pass over a rise or a dip in the track.

Very evidently, as this is a continuous system, the track must be endless; that is, at the ends of the course the "down" and the "up" tracks must be connected by a curve. A number of schemes have been devised for carrying the cars around the connecting curve. The best plan seems to be the use of a wheel with an automatic clutch which seizes each car just as it leaves the screws and carries it around to the return screws.

The following are some of the advantages of this continuous variable-speed system: It does away with motormen, conductors, and guards, hence greatly reducing operating expenses. The entire line is operated from a single power station. As the shafts run continuously at constant speed, the load is almost constant, varying slightly with the number of passengers carried. The retardation of a car on approaching a station contributes energy to the shafts which, farther on, is used in accelerating a car that is leaving the station, there being no brakes with resulting wear of wheel tires. Owing to the constant speed, no more suitable prime mover could be desired than the simple alternating-current motor. This motor requires practically no attention. It will operate with high-tension current, thereby minimizing copper in cables and entirely saving costly sub-stations and other complicated accessories to the present subway system. Transmission losses, such as are common to the ordinary third-rail systems with the sliding shoe contacts and consequent destructive earth currents, are done away with, as well as all danger of injury to the workmen or by fire in time of accident from an exposed third rail. The entire system may be mechanically considered as one vast machine under control of a single engineer at the power-house switchboard. No signal system is required, as there is absolutely no possibility of a collision except in the event of a breakdown. But the chance of a breakdown of any of the cars is exceedingly remote, owing to the fact that there are no complicated parts to become disordered, and that the axles and engaging projections can be made enormously strong. To be sure, this system is hardly adaptable to a long line, but the inventors believe that it might be applied to short crosstown lines or, by arranging the driving shafts in chords, on bridges.

In addition to this horizontal system, the Messrs. Adkins & Lewis have devised a continuous variable-speed elevator system which moves very slowly past floors, but travels swiftly between floors. A modification of this system has been devised for use at elevated and subway stations for carrying passengers to and from the street level. In this arrangement the cars move horizontally at the top and bottom of the shaft, long enough to permit passengers to step aboard or alight, and then they assume the vertical course and travel at high speed between levels.

Another application of the system is in the nature of the well-known escalator, which is becoming popular at department stores. The new design provides a series of seated cars moving slowly and horizontally in a semicircle at each floor and passing at relatively higher speed up or down an incline between all the floors.

This system is extremely flexible and can be applied in many useful ways for the transportation of passengers or merchandise.

Industrial Alcohol.*

The value and significance of a tax-free alcohol have been so widely discussed in the press and periodical literature of the entire country, that it is hardly necessary to emphasize the great importance of this subject, especially to our agricultural and industrial interests, since the new alcohol law became operative on the first of the year. For years we have been far behind the nations of Europe in this regard, and in consequence, our literature has been sadly lacking in authoritative works covering this phase of industrial activity. "Industrial Alcohol, Its Manufacture and Uses," recently issued by the publishers of the Scientific American, was designed with the especial purpose of supplying this want; it is the latest and most comprehensive work of its kind which has been published in this country. The book is a practical treatise, and will be found especially valuable by the layman and the student, notwithstanding that it is well adapted for use as a handbook by the expert. It comprises the researches and writings of the most eminent of Germany's specialists in the science of fermentation and distillation, being based upon Dr. Max Maercker's "Introduction to Distillation," as revised by Drs. Delbrück and Lange. The book covers the manufacture of alcohol from the raw materials to the final rectified and purified product. An introductory section deals with the importance of the new law, what it means to the farmer and the manufacturer, and the possible conditions arising under the law. In additional sections the methods of denaturing, the domestic utilization of alcohol for heating and lighting purposes, its use as a fuel for power production, and a statistical review are given. The discussion of the use of denatured alcohol for heating and lighting and for power productions is supplemented by numerous well-chosen illustrations; the entire text is fully illustrated throughout. In an Appendix is given the complete United States law. Few in number are those to whom this book would not prove of interest and value. The farmer, the manufacturer, the power producer, the householder, will all find that denatured alcohol is of importance to them, that its use and introduction will render feasible savings and economies which were hitherto impossible of accomplishment.

The Death of Prof. Ernst von Bergmann.

Prof. von Bergmann, the famous surgeon, died in Wiesbaden on March 25. He was operated on for intestinal disorder without an anæsthetic, and bore the prolonged cutting with the greatest fortitude, although he did not direct the surgery, as he did in the case of a previous operation some months ago.

Ernst von Bergmann, the celebrated German surgeon, was born in the Baltic province of Livonia on December 16, 1836. He studied at the universities of Dorpat, Vienna, and Berlin, and was graduated from the medical department of Dorpat in 1864. During the Austro-Prussian war of 1866 he was placed in charge of the military hospital at Königinhof, in Bohemia, and during the Franco-Prussian war he was at the head of the military hospitals of Mannheim and Carlsruhe. In 1875 he was appointed to the chair of surgery in the University of Dorpat, remaining there until the breaking out of the Turco-Russian war, when he became attached to the Russian army of the Danube as consulting physician. Returning to Germany, Dr. von Bergmann was made surgeon in chief of the hospital at Würzburg and professor of surgery at the university. In 1882 he was called to the chair of surgery at the University of Berlin, to succeed Prof. von Langenbeck, and also had charge of the surgical clinic of that city.

* Industrial Alcohol, Its Manufacture and Uses. A practical treatise based on Dr. Max Maercker's "Introduction to Distillation" as revised by Drs. Delbrück and Lange. Comprising Raw Materials, Malting, Mashing and Yeast Preparation, Fermentation, Distillation, Rectification and Purification of Alcohol, Alcoholometry, the Value and Significance of a Tax-Free Alcohol, Methods of Denaturing, Its Utilization for Light, Heat and Power Production, a Statistical Review, and the United States Law. By John K. Brachvogel, M. E. 528 pages, 107 engravings. Price, $4.