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Rose-Hulman Institute of Technology, library@rose-hulman.edu

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THE TECHNIC.

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THE war which is now being carried on in the far east has, of course, attracted the attention of all. The eyes of the engineering world especially, are fastened on that part of the globe where the latest mechanical devices for waging war are now being tested. Many of the intricate and most delicate contrivances which are found on modern warships have been supplied because of their theoretical or supposed value. The time is now at hand when their practical utility and worth can be proven. Who knows what this war may do toward revolutionizing the fighting craft of the powers of the world!

It is interesting to note that two of our graduates have been indirectly connected with the combatants. One of them, Taro Tsuji, '90, is a Jap, and we understand that he is now holding a high engineering position is his country. The other man we refer to, is F. W. Schneider, '98, who superintended the electrical work on one of Russia's largest battleships. We quote from the *Terre Haute Gazette* of February 21, 1904:

The Russian battleship Variag, which was wrecked in the recent naval battle with the Japanese, was delivered to the Russian government by an ex-Rose Polytechnic student. He is Fred W. Schneider, son of William Schneider, a dealer in fancy goods in Evansville. He is now electrical inspector for the city of New York.

Mr. Schneider graduated from the public schools at Evansville and then entered the Rose Polytechnic at Terre Haute, from which institution he graduated about six years ago. Shortly after his graduation he secured a position as an electrical engineer with the General Electric Company at New York.

When the Russian government gave the contract for the battleship Variag to the Cramps, Schneider was selected by the company to superintend the electrical work on the big fighting machine. Mr. Schneider remained with the ship for almost two years before the last piece of intricate machinery was installed. When the vessel was fully completed the question of who should deliver her to the Czar arose. Officers and crew were sent to man her, but etiquette demanded that she be formally presented to the ruler of the Russians by some one representing her builders. The question was finally decided by a vote and Mr. Schneider was selected for the honor by a large majority.

In the full uniform of a Russian naval lieutenant he sailed on the Variag when she left for Russian waters. The Czar was much impressed with the young American.

UNDER promise of great secrecy we have been shown several of the drawings of the *Modulus*, '05. They are fine. In fact, we were astonished to see that Noughty Five could claim such artists. There are drawings to please all.

Some will surprise you, and even now we can imagine what outbursts of laughter and smiles of appreciation the humorous features of the book will bring forth from its readers.

The fact that we at Rose can find time to publish a college book but once in two years should make the success of the *Modulus* a certainty. From all appearances this year's *Modulus* will break all former records, and it's sale is bound to be large. We can assure the Alumni that the book will be one which they cannot afford to be without. Their good old times at Rose will be brought back by drawings and lively sketches of college life. In fact, the whole make-up of the 1905 *Modulus* will be first rate, and we advise you to order at once from the Business Manager, Mr. Goodman. You will need two, of course, one for her and one for yourself.

MANY summaries of the career and work of Thomas A. Edison have appeared in technical journals lately owing to the celebration of his birthday by the *American Institute of Electrical Engineers*. The noted inventor was the guest of honor of the Engineers at a banquet given on his birthday, the eleventh of February. Mr. Edison is fifty-seven years old, and his continued activity in scientific research gives promise that he has many more useful years to live. At this banquet the *American Institute of Electrical Engineers* founded what is known as the Edison medal, which is to be awarded by the institute for distinguished achievement in electricity. The perpetuation of the name of our country's greatest inventor in this manner is indeed proper, for Edison's versatility in the field of applied electricity is most remarkable. To us it may appear that most of his great work was done on the spur of the moment by virtue of his inventive inspiration. But those who know the man and are familiar with his ways tell how he has grappled and struggled to overcome many difficulties. In fact, one is safe in saying that hard study and tiresome work preceded every invention that he has ever made.

SUCH rapid advances have been made in some of the numerous applications of electricity within the past few years that students often find it difficult to "keep up with the times." When wireless telegraphy was first heard of, it was only natural that many people should laugh at the idea, as they did at Morse's telegraph and Fulton's steamboat. And like these great inventions, in their early days, the wireless system is fast proving by its achievements that it will soon be the world's great medium of rapid communication.

THE TECHNIC takes pleasure in publishing in this number, an article by President Mees on the wireless telegraph, its growth and development up to the present.

SOME time ago the Athlectic Directors decided to have different style "R"s for the several branches of athletics instead of the one kind which has hitherto been awarded to men on all teams who have earned them. A notice of this decision was written in the form of minutes of the meeting, and posted in the Camera Club case. All students were invited to hand in suggestions for different styles of "R"s. The Secretary of the Athletic Association informs us that up to the present time he has received no drawings nor suggestions of any kind whatever. It's about time that we were attending to the matter. Baseball season will soon open and we'll need a few "R"s. Surely some of us ought to have some good suggestions, and the Directors should have a good number of designs to choose from. The single letter, R, is what is wanted, and all are invited to hand in their idea of what would make a good style for each team.

WIRELESS TELEGRAPHY.

By PRES. C. L. MEES, Ph.D.

THE term Wireless Telegraphy has been very generally applied to the system of communication by electrical disturbances brought into prominent public notice through the labor of Signor G. Marconi. Probably it would be better to use it in a more general sense and apply it to the several methods of signalling at a distance which dispense with the wire conductors used in the ordinary methods typified by the so-called Morse System. Used in this sense wireless telegraphy is one of the most ancient arts. We read in history back to the very beginning of fire signals, smoke signals, flag signals, sound signals, etc., used not only as signals for one or two prearranged sentences or words but for communication of messages. The study of the history of telegraphy from the earliest time until to-day is most fascinating and well worthy of attention. Many results achieved to-day and counted most marvelous, are found to have been predicted years ago, not as visionary dreams and wild fancies only, but having a basis in studies and investigations made. By far the greatest number of devices used experimentally and to some extent in practice belonged to the category of wireless telegraphy. Leaving out of consideration all the wireless methods employed not involving directly the use of electricity, the methods where electricity is the agent may be classified into three systems: 1st. By the conduction of electricity through soil and water, as the Oerling-Armstrong System. 2nd. By induction through space, as especially in Preece and Trowbridge work. 3rd. By the radiation of Electro-Magnetic Waves, known as Space Telegraphy—Ether Telegraphy, Herzian or Marconi Telegraphy. The latter name, perhaps most common, but least justifiable.

In this brief article the attempt will be made to explain very elementarily the principles involved and the most common devices employed in the last class only. The history of this class is most interesting. As early as 1831 the possibility or probability of making use of electric ether disturbances was foreseen by Faraday, and from that time on was steadily being kept in mind. Little by little, with added knowledge and greater experience, progress was made until, with the at least partial practical perfection to-day, there are linked the names of Maxwell, Herz, Lodge, Oneste, Branly, Marconi. Following these, there are at work many whose names in the future will appear prominent in further development. The method depends primarily upon an apparatus by which electric waves can be generated which are transmitted through the ether and an apparatus which, as these ether waves sweep upon it, will produce some effect, which may be made noticeable to our senses. The former is called a sender, the latter a receiver. Upon the discovery, or rather perfection, of the receiver mainly depended the practicability. The phenomena may then be considered to be due primarily to wave motion in ether.

The main difficulties that present themselves to the ordinary reader in the understanding of this method of communication seem to be, first, the conception of the ether which to many seems but a medium imagined by scientists; second, that waves should be able to pass through stone walls, and other obstructions which are characterized mainly by their impenetrability. The careful thinker will, however, easily convince himself of the reality of the ether, so-called, if he but reflect upon well-known phenomena. Every one recognizes at once that we can only become cognizant of the existence of anything through some effect upon our senses, though not always in a direct manner. We see the sun because by some means it can effect our eye, which means that something comes to us from the sun. It can be definitely shown that the disturbance which affects the eye is of the nature of a wave

motion. These waves can be measured and counted, and the velocity with which they are transmitted to us from the sun through the intervening space has been measured with great accuracy. It is unthinkable to us that there can be a wave without something in which the wave can form, for there is motion and energy transfer; thus the idea of a necessary medium possessed of such properties that the kind of waves we measure, count and appreciate can exist and be transmitted is imperative. If these properties seem strange or unlike, at least in degree to properties with which we are acquainted in other matter surrounding us, it need not greatly surprise us, for the bounds of knowledge and our conceptions are constantly being extended.

Quoting from a lecture delivered by Prof. Rowland: "Thus the ether is a much more important factor in science than the air we breathe. We are constantly surrounded by the two, and the presence of air is manifest to us all; we feel it, we hear by its aid, and we even see it under favorable circumstances, and the velocity of its motion, as well as the amount of moisture it carries, is a constant topic of conversation. The ether, on the other hand, eludes all our senses, and it is only with imagination, the eye of the mind, that its presence can be perceived. By its aid in conveying the vibrations we call light we are enabled to see the world around us; and by its other motions, which cause magnetism, the mariner steers his ship through the darkest night when the heavenly bodies are hid from view. When we speak in a telephone, the vibrations of the voice are carried forward to the distant point by waves in the ether, there again to be resolved into the sound waves of the air. When we use the electric light to illuminate our streets it is the ether which conveys the energy along the wires as well as transmits it to our eye after it has assumed the form of light. We step upon an electric street-car and feel it driven forward with the power of many horses, and again it is the ether whose immense force we have brought under our control and made to serve our purpose—no longer a feeble, uncertain sort of medium, but a mighty power, extending throughout all space, and binding the whole universe together."

The second difficulty, namely, that waves may pass through substances such as stone, earth, etc., without considerable loss in energy, will not be so hard to understand. Let it be remembered that in light and heat phenomena, as well as in sound, there are many cases of selective absorption and transmission familiar to every one. Take the case of colored glass—say red. Such glass may be pratically impervious to all the waves shorter than the red light waves but quite transparent to the long red waves, or blue glass opaque to all the longer waves and transparent to the short waves. Colorless glass makes an excellent fire screen as the long heat waves from glowing coal cannot pass through it while the shorter light waves that affect the eye and enable us to see the glowing coal are transmitted with but little dimming of brightness. Familiar instances of this kind could be multiplied; they need only serve as illustrations that a substance which is opaque to one kind of wave, may be quite transparent to one of different dimensions or character. The fact that wood, earth, stone, etc., are transparent to long electrical waves and opaque to light waves, is no more remarkable than that red glass is transparent to long waves of red light and opaque to blue or violet.

It will probably assist the reader if we now compare the function of the electric radiator and receiver for telegraphic purposes with the action of sound wave producers and receivers used for sound signalling. The powerful steam sirens used upon the Atlantic coast to signal vessels in a fog, may serve as illustrations. The siren usually consists of a long metal tube generally trumpet-shaped. At the bottom of the tube there is fixed a plate with holes in it arranged in concentric circles; against this there is placed a similarly perforated plate capable of being rapidly rotated. These two plates separate a wind or steam chest from the trumpet-shaped tube. Into the wind chest, air or steam under high pressure can be admitted; as the movable plate revolves the holes are alternately brought into

coincidence and opposition and powerful puffs of air or steam are projected into the tube. If these puffs come at the rate of say 100 per sec. aerial oscillations or air waves which impress the ear as a deep note or roar are generated. If the inlet pipe to the air chest be controlled by a valve, a series of long and short blasts may be combined into signals standing for letters. Words and sentences may thus be transmitted. The location of a light-house may be made known to a ship by this means when the light from the lantern is absolutely hidden by the fog.

The production of a sound wave in air can only be achieved by administering a very sudden blow to the general mass of air in the tube. The impulse must be sufficient to bring into play the inertia and elastic properties of the air. Inside the siren tube the air particles are in rapid oscillating motion in the direction of the length of the tube. If we, at any instant, examine the the distribution and changes of air pressure in the tube, we will find that at some places there are large and at others small variations of pressure. Where the pressure variation is largest the air particles have the lowest velocity. This point is called a node. Where the pressure variation is least the air particles have the greatest velocity. That point is called an antinode. Outside of the tube, as a result of the oscillatory motions in it, hemispherical air waves are produced which travel outwards from the mouthpiece as a center. If we could examine these air waves by the eye directly it would be seen that we have a motion periodic as to time and space constituting the familiar air wave, the motion of which is similar in character to the vibration of a pendulum, or like ordinary water waves as observed upon a still pond where ripples radiate from a center of disturbance, such as a drop of falling water.

A tuning fork vibrating produces the same train of phenomena in air as described above. If the number of vibrations executed by the body producing the sound wave be known the length of distance from crest to crest of the air wave may be determined by dividing the velocity of sound propogation by the number of vibrations. Thus if the number of vibrations be 100 per sec. and the velocity of transmission 1,100 ft. per sec. the wave length will be 11 feet. In a stopped organ pipe the length of the pipe to produce the fundamental tone is one-fourth of the length of the air wave resulting. At the closed end there will be a node, at the open end an antinode, as described under the siren.

Turning to consider the production of electric instead of air waves, we notice that in the first place we have the ether to deal with, the same medium in which light waves are generated. The ether permits of physical changes in it analogous to, but not identical with, the pressures and movements which constitute a sound wave. The Herzian, or electric radiator is an appliance for acting on the ether as the siren, tuning fork or organ pipe acts on the air. It produces ether waves. It can be shown that the above sound apparatuses have their electrical equivalent in the transmitter employed in Herzian wave wireless telegraphy.

Without going into detail and discussing the hypotheses of electrical action, we will conceive of the ether as a homogeneous medium in which a strain or displacement, probably of a rotational kind, is possible. This strain appears under the influence of an appropriate stress called electrical force and disappears when the force is removed. To create this strain requires the expenditure of energy. Suppose, now, we have two metalic rods placed in line, having their ends separated by a very small air space. Let these rods be positively and negatively electrified, then the surrounded ether will be strained. This strain may be represented by lines of force similar to the lines of magnetic force revealed by iron filings between the north and south poles of a magnet. If the two rods be brought together the charges unite and the lines of force or strain collapse. A momentary rush of electricity occurs and with it circular lines of strain embracing the wire are formed, producing a magnetic field in the ether such as is noticed near any conductor carrying a current. The small air space between the metallic rods before they were touch-

ed represent a medium in which free motion of electricity is impossible, and for that reason strains in it once established will remain until by motion or redistribution of the electricity in neighboring conductors they are rearranged.

If, instead of the above described single rush of electricity between the two charged rods the operation be reversed and repeated there will be another effect produced. Imagine that the rush of electricity between the two rods be from the right positive to the left negative, then repeated from the left negative to the right positive and so on, strain lines will be thrown out of both kinds, electric when there is a static charge in the plane of the wire and magnetic while there is a rush of charges embracing the wire. These will collapse and be thrown out in the opposite sense when the charging and the flow in the rods is reversed. If the elastic and inertia properties of the surrounding medium are such that the lines cannot collapse upon the rod from the surrounding medium as rapidly as the electric charges move back and forth in the conducting rod, they will lag behind and form loops of strain or waves which will radiate or travel out from the wire into space. We have the same condition found when a sound wave is sent out from a vibrating rod. If the rod move back and forth so slowly that the air can flow around and follow the motion of the rod, air displacement alone will result; if, however, the rod vibrate more rapidly than the air can follow in flow, waves of sound consisting of compressions and rarefactions will be formed and will radiate from the fork.

Turn now to the Herzian radiator illustrated in Figure 1. A is an aerial rod, E a rod and plate buried in the earth separated by the air space. A is negatively charged, and as the whole earth is a part of the rod E, strain lines will be thrown out from A to E as shown in the figure. If a spark now jump between A and E the insulation of the air is momentarily broken down and the charges rush together. If A and E are sufficiently good conductors the rush will be more rapid than it is possible for the strain lines in the surrounding medium to follow and there will be a condition represented by the second figure.

It was shown early in the fifties by Fedderson,

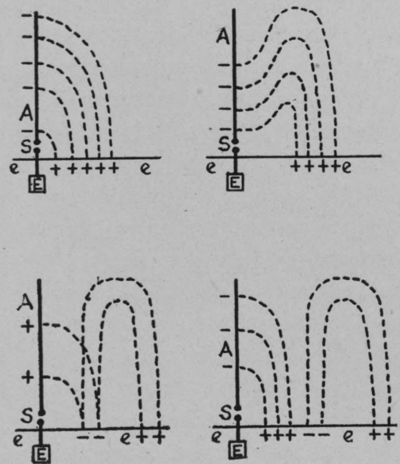


FIG. I.

Thompson and others that when such a sudden rush occurs the electricity overshoots the mark, as it were, behaves like a substance having inertia, and the rods become oppositely charged and this process is repeated until by frictional or similar effects they are dampened into equilibrium. The third figure represents the result of the overshooting; the rods become oppositely electrified from their first condition, A positive and B negative. A new set of reversed strain lines are thrown out before the first have collapsed; the first are cut off and travel out from the conductor as loops in the ether closed through the earth. They thus travel across the country with their lower ends anchored to the earth carrying away some of the energy which charged the rods. If new energy be not supplied to the rods it follows that each succeeding wave is feebler and a rapid decay of the oscillations in the rod results.

The amount of energy stored in the original charges is readily caculated. If C stands for the capacity of the aerial in microfarads, V the potential in volts to which it is raised before discharge, then the energy in Joules will be $E = CV^2/2.10^6$. For short sparks between 5 and 15 m. m. the voltage under ordinary atmospheric

conditions is roughly 3,000 volts per millimetre. The Joule is approximately equal to three-quarters of a foot pound; we may write, calling S the spark length in millimetres, and F the energy in foot pounds, $F=27CS^2/8$. An ordinary aerial 150 ft. in length of 7-22 stranded wire, insulated and held vertically, its lower end near the earth, has something like a capacity of about one three-thousandth of a microfarad, with a spark of one centimetre the energy stored before each discharge will be only about one-tenth of a foot pound. Of this only a portion is radiated, much energy being dissipated as heat, light, etc.

The problem of long distance transmission then is one dependent upon the recognition of very small quantities of energy. The Marconi transmitter consists essentially of the two rods as above described supplied with an electric generator capable of charging and recharging the metallic rods.

The aerial rod may be compared to an electric organ pipe in which electric oscillations occur similar to the air vibrations in the organ pipe. The analogy is shown by the illustration. Fig-

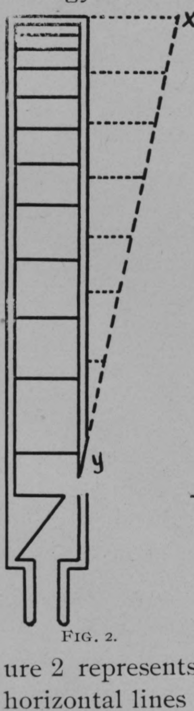


Fig. 2.

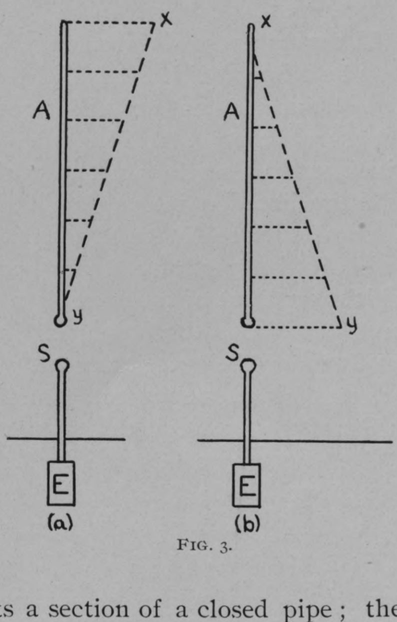


Fig. 3.

ure 2 represents a section of a closed pipe; the horizontal lines enclosing spaces which represent amplitude of oscillation. The pressure variations are represented by the length of the ordinates of dotted lines. At x there is the greatest pressure variation, at y the greatest amplitude and least pressure variation. The diagrams of the aerials in Figure 3 show the same relation of electrical change. In A the pressure distribution, in B the current distribution is indicated by the dotted line ordinates. From these electrical waves are sent out as are the sound waves from the organ pipe.

It will be apparent that the question of transmitting signals by electrical waves is largely one of associating sufficient energy with the aerial wire or radiator. This may be done by increasing the capacity or voltage, or both. If the spark length be increased too much, the resistance becomes so great that the spark ceases to be oscillatory, and no radiation results. With an ordinary induction coil the limiting length of spark effective is about one centimetre, representing a voltage of from 30,000 to 40,000 volts. By the use of a transformer oscillatory discharges having a voltage of from 100 to 200,000 volts may be obtained giving sparks from 5 to 6 centimeters in lengths. This was one of the improvements that brought wave telegraphy a step nearer to the practical. The capacity of the aerial may be increased by multiplying the aerials, but experiment reveals the fact that the increase of capacity is not proportional to the number of wires. If the aerials are parallel, separated about three per cent. of their length, the capacity of the whole lot varies approximately as the square root of their number. Increase of capacity of the aerial as a means of generating more energetic waves presents difficulties. Various fanciful arrangements of wires have been devised, but are efficient mainly in the minds of their inventors.

The greater improvement has come in the invention and arrangement of condensers, coils and tranformers to produce continued oscillations representing a greater amount of energy than the spark discharges between aerials of the original Marconi type. Brown's and Slabey's arrangement, Tessla's and Fesserson's devices, are

directed to this end, and considerable success has been achieved.

We turn next to devices for the detection of waves, or receiving apparatuses. For sound waves we have the mecanism of the ear, or a sensitive flame may be used which ducks whenever a sound wave passes over it. For light waves we have the eye or the photographic plate. The latter reveals in addition shorter waves than will affect the eye, but precisely similar in character, for the recognition of which we have no special sense. We learn of their existence only by detecting them indirectly through their chemical action or ether effects. Electrical waves do not seem to affect any of our senses directly ; for this reason they escaped physical detection so long. Their existence had been predicted by Maxwell in the early sixties, who discussed them fully. Herz, in 1885, discovered almost accidentally a method for detecting the electrical oscillations. He was interested through the vivifying stimulus of his teacher, Helmholz, as early as 1878 in the detection of electrical ether waves. During the delivery of a lecture in the Technical High School at Carlsruh, he noticed that whenever an oscillatory spark jumped between the terminals of a flat coil through which a small Leyden jar was discharged, an electric current accompanied by a tiny spark was produced in a similar neighboring coil. In a series of most brilliant experiments extending over a number of years, an exhaustive study of electrical waves was made by him and the means found by which they could be studied. Maxwell's theory was experimentally verified, the similarity of light waves and electrical ether waves demonstrated.

This discovery and these studies mark the birth of the kind of telegraphy we are discussing ; the name of Herzian Telegraphy and Herzian Etherwaves seems appropriate. The phenomena noted by Herz are essentially resonance phenomena, having their analogies in sound. If an organ pipe generates aerial waves and if these radiating waves are intercepted by a similar pipe the energy of the waves will be absorbed by the air column in the pipe which will be set into oscillations, an ear placed near the pipe will hear a sound issuing from the second pipe. The second pipe has become a receiver of waves. If the pipe has its sides perforated with holes covered by thin membranes they will serves to register changes of pressure upon the inside. The motion of these diaphragms can be made visible by various devices, and sound waves can in that manner be made visible or recognizable by other senses than the sense of hearing. By the application of this principle it is possible to make music visible. A thin soap film studied by reflected light may be made to give a beautiful picture of harmony and concord. The electrical ether waves produced by an oscillating transmitter, which we have likened to an electrical organ pipe, travel along in a similar manner through the ether. If they encounter or sweep down upon a precisely similar arrangement to the radiator there will be produced electrical surgings in the conductors like the ones which produced the waves sent out, only they will be of much less intensity. The oscillations will represent only an amount of energy equal to that portion of the wave which is intercepted. We have the same train of phenomena as described in the case of organ pipes.

The minuteness of the energy amount absorbed may be inferred if it is recalled that for a 150 ft. aerial about one-tenth of a foot pound is the total energy of charge. If, say one-half of this is given out to a single wave, and this wave radiate in every direction into an approximately hemispherical surface, let us say ten miles in radius, and only that part of the energy can be effective which is cut out of the wave by a wire 150 ft. in length and a tenth of an inch in thickness the smallness of the energy amount which has to be detected becomes apparent. In the practical solution of this problem, this was the difficulty.

The discovery of Oneste, in 1886, that metal filings were made to cohere when in the neighborhood of an oscillatory discharge, gave the first suggestion for a really sensitive detector for electrical oscillations. Lodge, in 1889, showed that two balls placed very near together, yet of-

fering considerable resistance to an electric current, would when near an oscillatory discharge, permit a minute spark to pass and become sufficiently welded to make them good conductors. If they were part of an ordinary electric bell circuit before the spark passed the bell would not ring, but immediately the spark passed the resistance would be reduced sufficiently to ring the bell.

In 1890 and 1891 Branly used metal filings, such as Oneste had used, substituting them for the metal balls of Lodge, and made the so-called coherer so sensitive to electrical oscillations that wave telegraphy through a considerable distance became possible. The elements already described for the simplest arrangement for reasonably effective wireless or Herzian telegraphy are shown in Figure 4. On the transmitter side we have the battery, B, and key, K. By closing the key, a current is sent through the primary wire, P, of an ordinary induction coil, producing in the secondary, L, high pressure or voltage currents which charge the terminals, T T, separated by a

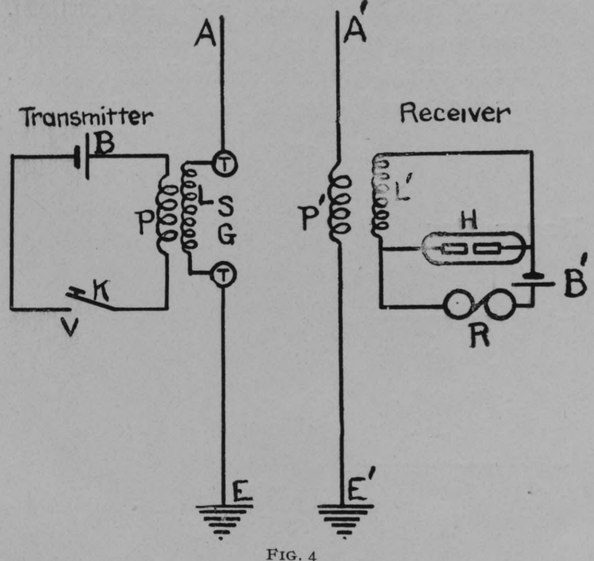


Fig. 4

spark gap, SG. T and T are connected to the aerial, A, and the earth, E. As a spark leaps across the gap, SG, electrical oscillations are set up in A, which constitutes our electric organ pipes. Electro-magnetic waves are radiated, and are somewhere intercepted by A'E', similar in disposition to the transmitter, but without a spark gap. Oscillations are produced in A'P'E'. By a step-up transformer their voltage is raised in L' until the little sparks pass through the coherer, H. The coherer consists of two small metal plugs enclosed in a glass tube which they fit snugly, separated from one another by the small fraction of an inch the space between loosely filled with metal filings. The contact between these is so poor that the battery will not actuate the relay, but as soon as the oscillating sparks spoken off pass through the tube with the filings, it becomes a good enough conductor to actuate the relay. Let the filings be shaken up and the conductivity is again reduced so that the relay opens, to be restored when oscillations cause them to recohere.

A somewhat more detailed view of the arrangement adopted in some receiving circuits is diagrammatically shown in Figure 5. The oscillations from the vertical rod passing to the earth through the coherer increase the conductivity so much that the battery can send sufficient current through the high resistance relay magnet

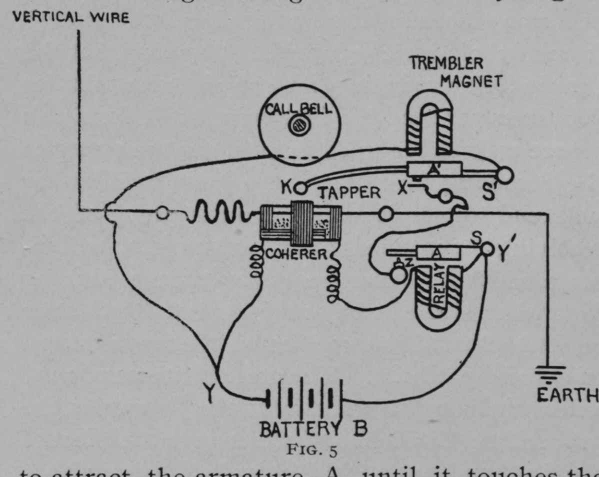


Fig. 5

to attract the armature, A, until it touches the contact point, Z, and sends a current from the same battery, through SAZXA', the bell magnet, and back to battery. The vibrating bell tapper, K, serves to produce a sound signal, and at the same time tapping the coherer, resensitizes it for the following oscillations.

The simple circuit just described is more or less sensitive to electrical impulses and electrical waves of widely varying length. One receiver may be affected by waves from several senders, resulting in confusion of signals. This was a formidable difficulty encountered at once in the attempt at practical application. It may be overcome to a considerable extent by the full application of the principle of resonance. Using the acoustic analogue again, if the sounding body send out a series of feeble sound waves continuously and they impinge upon a body which itself has a definite period of vibration, the receiving body will be set in vibration if its period be equal to that of the sounding body, but will fail to respond if unequal in period. Let two tuning forks, tuned to exact unison, be placed at some distance from one another, and say a third of a slightly different pitch at the same distance from one. If one of the two similar forks be made to vibrate, the other will pick up the vibrations and sound audibly; the one of different pitch will remain silent. Many acoustic and mechanical experiments illustrate the same principle. The explanation is not difficult. The receiver or resonator acts as an accumulator and collects the energy from a whole series of waves. Suppose that the tuning fork producing the sound waves vibrates 200 times per sec., the first wave crest from this source may be regarded as pushing the prong of the receiving fork along, the trough following will tend to pull it back. As the prong of the receiving fork, tuned to the same pitch, will vibrate with the same frequency as the sending fork when started, the prong will of itself start on its backward journey just as the wave trough tries to help it back. The crest of the next wave will again help the fork in its motion forward at the proper time, thus adding its energy to the effect of the first, and so on; the second will accumulate the energy from the first at the rate of that from 200 waves per second. If the receiving fork be not tuned to the same period, the forward and backward impulses from the waves will come into more or less opposition with the natural vibrations of the fork, so that the forward impulse of the wave may come when the prong of the fork is moving backwards, resulting in a neutralization of effects. The same principle is applied in giving motion to a "swing." If the impulses given be tuned to the natural period of the swing, accumulated motion results; if not so tuned, effort is wasted and the swing even stopped. An electrical transmitter capable of being tuned in unison with an electrical receiver will enable the energy from a train of feeble waves sent out from the transmitter to be accumulated by the receiver until a large effect is produced. Waves not properly tuned will not produce appreciable effects.

The period of vibration in an oscillatory circuit is determined by the capacity and self-induction of the circuit. The capacity corresponding to the elastic constant in a tuning fork and the self-induction to its inertia. If I is the period, L the self-induction, R the resistance and C the capacity, the relation is: $T = 2\pi\sqrt{\frac{4CL}{4L - CR^2}}$ From this it will be seen that a radiator may be tuned by any arrangement which will enable one to vary its self-induction or capacity, or both. Just as a tuning fork may be tuned by loading its prongs or thinning them by filing or both. The receiver may be tuned in a similar manner.

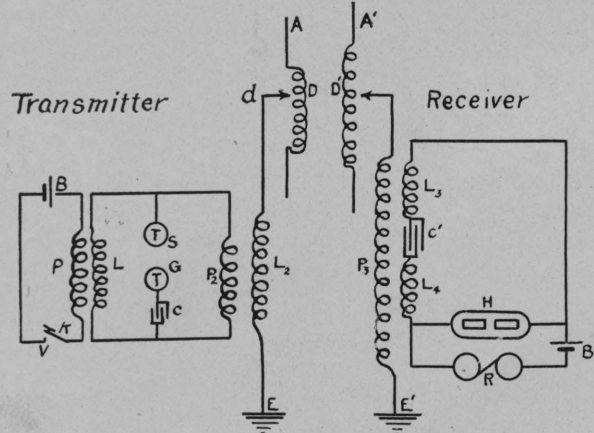


FIG. 6

In the Figure 6 an arrangement of this kind is shown. On the transmitting side B is the battery or other source of energy, P the primary of the induction coil, T and T electrodes, SG the spark

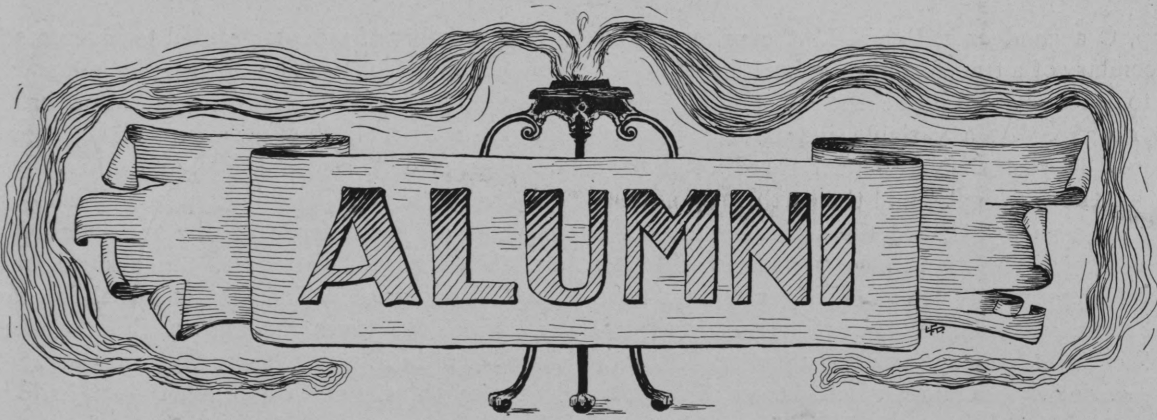
gap, C a condenser, P_2 and L_2 the primary and secondary of a transformer, the function of which is to intensify still more the oscillations in the spark gap. A, a variable inductive resistance placed between the vertical aerial rod, commonly called the wave gate, and the earth. By adjusting the capacity, C, and the self-induction, D, a considerable variation in the period of oscillation may be produced. On the receiver side we have the same general arrangement. D variable self-induction, P_3 primary of a transformer, L_3 and L_4 the secondary containing a condenser of variable capacity, H the coherer, R & B relay and battery. This circuit can then be tuned by adjustment of C′ and D′ until it will vibrate in unison with the transmitter, so that it will only respond to electrical waves of that period and be insensitive to other wave lengths. With such a divice two stations may be arranged so that they will only be sensitive to one another's signals, unless their period be known and others tuned to unison.

Since the study of electrical waves by means of the coherer, it has been found that a great many different devices could be used for their detection, and that a great many oft-noted disturbances may be traced to the effect of these electrical waves. A whole series of wave-responsive devices, radio-receivers, detectors, etc., have been invented and patented. No attempt at description will be made; they may, however, be classified into coherers, anti-coherers, microradiophones and magnetic radio-receivers. In the first and second class, as the names indicate, the effect is reversed. In the third class the microphone principle is used. In the fourth, changes in a magnetic field resulting from the oscillations serve for making them known. Several other effects have been utilized.

The number of patents granted to inventors in connection with Herzian telegraphy runs well into the hundreds. Practical application has so far been limited, though substantial progress has been made. Houses, hills, and other physical obstructions if they be not metallic do not very seriously interfere with the transmission of signals to limited distances, the electric wave length being great. The character of the surface over which the waves travel has much more effect. As shown in Figure 1, the waves are anochored to the earth, the earth closing the strain loop. If the surface over which they travel and through which these lines are closed is a poor conductor, wave transmission becomes difficult because of great energy dissipations. Where the surface is water, a relatively good conductor is assured. For this reason most of the successful trials in long distance transmission have been made over bodies of water.

It can not be doubted that signals have been successfully exchanged across the Atlantic. On January 19th, 1903, a message was so sent from President Roosevelt to Edward VII. The message was transmitted from Wellfleet, Cape Cod, to Table Head, Nova Scotia; from there to Poldhu, England. The Poldhu station, however, was able to take the message as it was transmitted to Table Head.

It is probable that even with the present limitations and imperfections a very useful field will be found for Herzian wave telegraphy. What it may develop into, cannot well be predicted. It is, however, fairly safe to say that wonderful as have been the achievements to this time, it will supplement but not supplant telegraphy by wire or cable.



The Copper Country.

By O. P. HOOD, '85.

THE southern shore of Lake Superior is divided into two nearly equal parts by a bold spur projecting some seventy miles northeast into the "great unsalted sea," into the "shining big sea water." There are but few hours during the period of navigation from May to November when the bold headlands of Keweenaw point are not within sight of some one of that great fleet of vessels which has made the "Soo" the busiest of the world's canals, and that route around the point a busy highway. This extreme end of the peninsula, however, must now satisfy the visitor with its delightfully cool summer climate, picturesque views of lake and stream, forest and hill, good fishing, and tales of the past, for at present it is practically deserted, reached by neither rail nor regular boat. Here one wanders between abandoned pits, crumbling shaft houses, deserted villages, and over trails thick grown with sizable second growth. Fort Wilkins, long since deserted, still shows a short section of the old stockade erected against Indians who never offended. This deserted district is now the picturesque back door of the "Copper Country."

Its active history centering about Copper Harbor was made early in the forties. Here much wealth and pioneer effort was spent and many hopes died, for copper was found on every hand but not in paying quantities. This view of the Copper Country is seldom seen, but is valuable as a foil to put beside that peerless district beginning some thirty miles southwest, which contains one of the richest mineral deposits known to the miner. Towards the base of the peninsula a narrow rift across the formation has allowed the lake to nearly sever the spur from the mainland by a waterway, deep and river-like in its narrow and winding course. The severance has been completed by a Government canal about two miles long, and on the shores of this inland water, known as Portage Lake, the neighbor towns of Houghton and Hancock string along at the base of 600 foot hills and consider themselves the front door to the Copper Country. It is here the summer tourist comes to enjoy the cool summer and the novelties connected with the great industry of copper production and deep mining. It is the excellence of both water and rail connection that makes this the now favored entrance to the district, although the early copper mines were near the extreme point of the peninsula and also some forty miles to the southwest in the Ontonagon district. It was in this latter district that the earliest explorers found great pieces of solid copper on hillside and stream bank or in shallow pits. But while these great masses of metallic copper, weighing from a few pounds up to one of 563 tons, were wonderful to behold, and, at the price of 50c per pound then obtained for copper, represented fortunes, they were in-


• MINES
★ MICHIGAN COLLEGE of MINES
LAKE SUPERIOR
COPPER HARBOR
KEWEENAW POINT
EAGLE RIVER
CALUMET
TORCH LAKE
HANCOCK
HOUGHTON
PORTAGE LAKE
KEWEENAW BAY
HURON BAY
ONTONAGON
GREENLAND
ROCKLAND
MASS CITY
COPPER RANGE
L'ANSE
MARQUETTE RANGE
MICHIGAMME
CHAMPION
MARQUETTE
ISHPEMING
NEGAUNEE
LAKE MICHIGAMME
REPUBLIC
BESSEMER
IRONWOOD
GOGEBIC RANGE
LAKE GOGEBIC
Montreal River
IRON RIVER
CRYSTAL FALLS
MENOMINEE RIVER
MENOMINEE RANGE
IRON MT.
QUINNESEC
VULCAN
NORWAY
D. S. S. & A. R.R.
CHI. MIL. & ST. P. R.R.
C. & NOR. W. R.R.
MAP
OF THE
MINERAL DISTRICT
OF
NORTHERN MICHIGAN.
Michigan College of Mines Catalogue.
FRANKLIN CO., ENGRS. CHI.

frequent and expensive to remove. The large one referred to is said to have taken 40 men six months to cut into pieces small enough to hoist. The middle district about Portage Lake possesses fewer of these large masses, but great quantities of rock are more uniformly impregnated with fine copper. Here, then, is a range a full hundred miles long where some copper could probably be found along every foot of length, did one only know where to look.

The rock formation is such as to furnish ample study to the geologist, yet the general features are readily grasped by the stranger. Successive lava flows frequently extend over miles of territory, built on an underlying sandstone, a thickness of several thousand feet of rock, varying from layer to layer in quality and physical character. Broken and sea-washed at times, conglomerate beds were formed of rock debris between the other rock layers.

Many of the lava flows show the open structure of amygdaloidal rock with its bubble-blown body and irregular scoriaceous upper surface. Something like 40 000 square miles of this kind of stratified formation lie beneath and around the western Lake Superior, its cup-like form holding the waters of the lake, its bent-up edges forming the hills and shore line of the lake from Keweenaw point around by Duluth to the Canadian north shore of the lake. Along Keweenaw peninsula these strata are inclined at angles of dip from $37\frac{1}{2}°$ to $72°$, dipping below the lake to rise again at Isle Royal and along the Canadian shore. Many of these parallel beds have been mineralized, the openings in the rock filled, not with an ore, but with pure metalic copper. In many places any rock open enough in character to harbor the metal has had its interstices filled and cavities loaded with the useful rose-colored metal. Some conglomerates appear as a concrete would, if the gravel mixed in were molten copper instead of cement mortar. The copper is supposed to have been deposited by percolating waters, but from what source is still doubtfully discussed. Any given property may therefore be traversed by several parallel copper-bearing formations one below the other, and only by extensive mining operations can it be told whether the copper is in sufficient quantity to pay. Paying mines are taking out rock that averages 1 to 3% refined copper, although one mine makes a living on rock running .61%. While the mining operations are relatively simple, they must be conducted on a large scale. Occasional lean streaks through an otherwise satisfactory lode must be met by a company having a large financial reserve and a mine having extensive openings to select from, in order that the production be kept uniform.

That great quantities of rock extending over miles of underground workings can be had containing a paying quantity of copper is the great advantage of this district; taken with the relatively simple smelting problems involved.

This makes a more permanent business than is usual in mining operations. It is this extensive scale of operations which adds greatly to the interest of the section. The upturned edges of the rock strata have been eroded and in many places overlaid by a heavy burden of glacial drift.

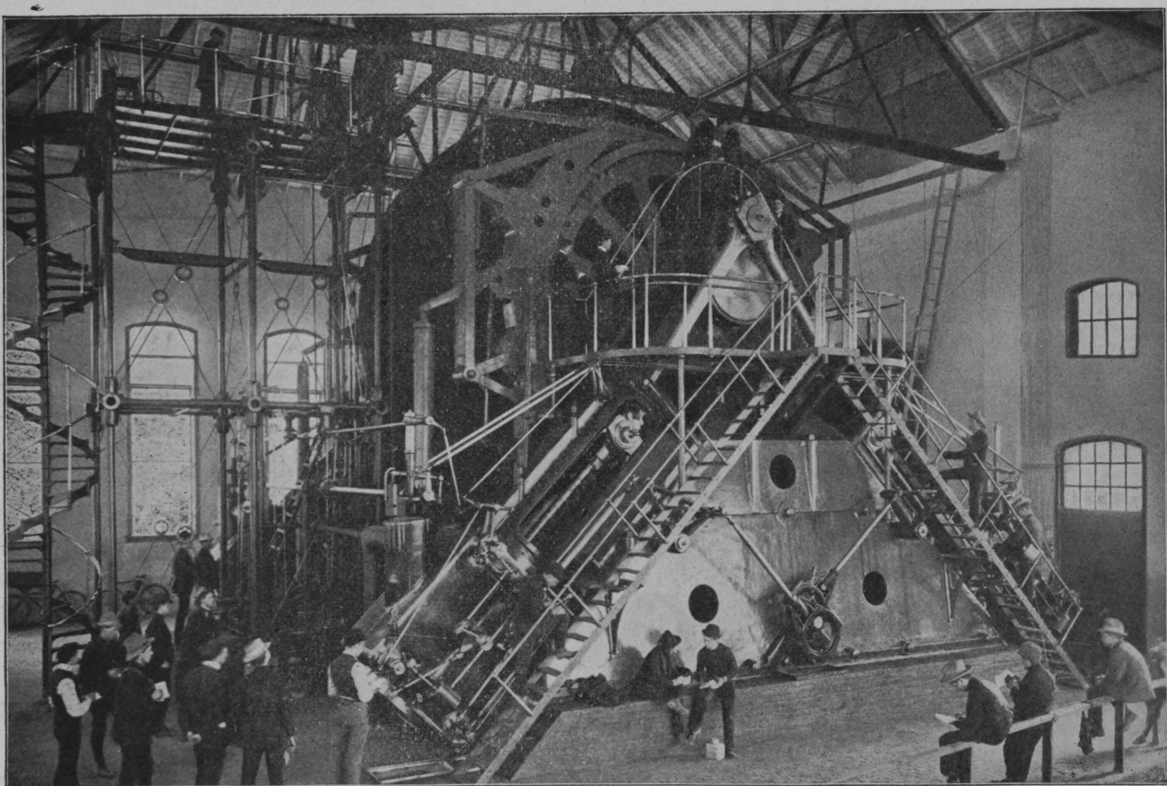
Native copper torn from the hills in glacial times is found scattered as far south as Illinois and Indiana. From the gradual reduction of the hills, a crude concentration left in some places rich deposits of this float copper. It was this, together with pieces torn from the ledges by fire and water and stone hammers, that was widely distributed by the Indians and hammered into shape for ornament and weapon. This native copper can be continuously hammered without cracking, although not annealed, the hardening due to the beating giving a rather inferior cutting edge in no wise equal to what we now expect of a tempered tool The so-called lost art of copper tempering is a myth, as there was no such art to lose except this simple hammering. Naturally the outcropping veins of value were first developed into mines, but there are long stretches of country in which no outcrop occurs carrying many feet of sand and gravel overburden, and heavily wooded, beneath which paying mines have been located and others likely will be.

Shafts are sunk on the dip of the lode about 1,000 feet apart, and these are connected by horizontal drifts about 100 feet apart. A plan of the worked lode would therefore look like a huge gridiron, the vertically inclined shafts carrying a railway or "skipway," ladder-ways, water, compressed air, and occasionally steam pipes, while along the drifts tracks are laid for tramming the broken rock to the shaft for hoisting. When a sufficient length of drifts have been opened to expose a large body of rock the lode, varying from 10 to 40 feet in width, is worked out to the drift above. This produces great caverns; the inclined ceiling being supported either by leaving pillars of poor rock, timber, or piles of waste rock.

Several miles of openings are needed before the mine begins to produce copper regularly. These mines are the deepest in the world, both vertically and on the incline.

Tamarack Number 5 shaft is vertical and 4,938 feet deep; 7 ft. x 29 ft. in section. Five years were required to sink to the inclined strata which was believed to carry copper. This was reached at a depth of 4,662 feet. Several other holes are nearly as deep, the Calumet and Hecla having inclined shafts over 6,500 feet in depth. To hoist rock from such a depth at a rate sufficient to ship 800 to 1,200 tons a day requires a good track, buckets holding five to eight tons, and very powerful engines. This immediately suggests a large field in which the mechanical engineer finds great interest and profit. The steam engineering problems are large and by no means simple.

A great variety of forms of hoisting engines can be seen here, from 5,000 to 7,000 horsepower, horizontal, vertical, simple, compound, triple expansion, condensing or non-condensing, geared or direct-connected. The problem is so



unlike the constant speed mill engine that the solution of the problem of cheap steam power is by no means obvious. The engine must start and stop frequently, be under instant control to move but an inch either way if necessary, have great starting torque, and above all be reliable. The engine shown in the cut is one of a pair hoisting from the deep vertical shaft referred to. Its characteristic is great simplicity, being composed of four inclined Corliss engines 36″ x 72″ direct connected to a conical drum capable of carrying 6,500 feet of 1½″ cable. The nominal rating of this engine is 6,500 H.P.*

In inclined shafts the men are lowered to work by replacing the usual rectangular rock bucket carrying wheels, which run on the inclined track, by a section of stairs 10 steps high, seating three men to each step, the section adapted to roll on the track. The interesting steam engineering problems do not stop with the hoist, however. The world's largest air compressor for mine work of 7,000 H.P. and capable of supplying air for 500 air rock drills, is at the C. & H. mine. It is well described in February *Power*.

There are many others of different types, one being installed of 1,400 H.P. quadruple expansion, using steam at 300 lbs. pressure and using the Noroberg cycle of feed water heating whereby it is expected to exceed any duty heretofore reached by any pumping engine. The general idea involved is to take steam from several points during its expansion and transfer its heat to the feed water. The air drills use air at about 80 pounds, and it is usually compressed in two stages. A large hydraulic compressor is being installed on the "Taylor" system. Water falls through a vertical shaft aspirating air through suitable nozzles and compressing it as it falls. About 4,500 H.P. is to be generated, using air at 125 lbs. pressure. The problem is one of hydraulics rather than of machinery, as there are no moving parts. There are many triple expansion pumping engines from 12,000,000 to 24,000,000 gals. capacity and one of 60,000,000. These great pumps are not needed at the mines which are fortunately comparatively dry, but are needed at the stamp mills. The rock is carried by short railroads to the mills on the shore of the lake, where each ton is crushed and washed with about 30 tons of water to separate the heavier copper from the rock. The crushing is done by steam stamps similar to steam hammers, in that they must have a variable stroke and the indicator card from the lifting end is quite unlike that from the down stroke.

These stamps must crush about 500 tons of hard rock per day so as to pass a screen having $\frac{3}{16}$″ to $\frac{5}{8}$″ openings. These are simple vertical steam cylinders, the valve gear for each being driven from an independent shaft and mill engine. Steam at 120 lbs. pressure is carried on the down stroke and cut off by a quick-acting Corliss valve a little after mid-stroke and exhausted into a good vacuum. The up-stroke is regulated by throttling the steam. The quick action of the down-stroke valve gear is obtained from eccentrics on an offset shaft driven by a drag link from a shaft running at a uniform speed. This latter carries eccentrics for the lower valves. Something over 60,000 ft. lbs. of energy is absorbed during the last inch of movement of the stamp as it comes to rest on the rock, which will give an idea of the blow. About 23,000 tons a day are thus stamped. Efforts to compound these stamp heads are now being made.

The copper as taken from the rock is classified as: "mass," those large pieces of 100 pounds or over; "barrel work," pieces readily packed in barrels; and "mineral," washed from the rock as fine stuff. All this is shipped to the smelter near by to be melted down in reverberatory furnaces.

The "mineral" runs about 73% ingot copper. The copper is refined, freed as far as possible from contained iron, oxygen, sulphur and arsenic, and is dipped in hand ladles and poured into molds in the form of ingots, wire bars, plates, anodes, &c. Nearly all the copper carries silver values, and probably $10,000 a month is obtained

* A detailed description of this engine can be found in the American Machinist, Sept. 14 and 21, 1899.

for silver. It occurs as pure metalic silver and appears as if welded to the copper. Some of the lake copper is treated electrolytically to obtain the silver. The electrical engineer finds interest in the underground electric tramming, pumping and extensive lighting, railway and power propositions.

One of the problems of the future is a satisfactory electric hoist for these great depths where a great starting torque and a quick trip are so necessary.

The United States produced last year in round numbers 375,000 tons of copper, or about 54% of the world's output. Michigan's share of this was about 100,000 tons. Probably about half the copper used is alloyed as brasses, bronzes, etc.

Lake copper is preferred for many kinds of work because of certain elastic properties which it seems to possess in a different degree than electrolytic copper. There has been paid in dividends from the district something over $120,000,000 since the first in 1849, and although many millions have been put into properties yielding no returns, yet the balance is still on the right side by many millions.

There are employed directly 15,000 or 16,000 men about the mines and mills, and a population of 65,000 or 70,000 is linked by electric lines and common interests to act much like a single community, although scattered along a range for 25 or 30 miles. It is a current expression that it requires $1,000,000 and three years' time to develop a copper mine in the Lake district, a condition not favorable to the small operator. That it is possible to dig thousands of feet into the earth, blast a ton from the solid rock, hoist it, transport it 5 to 20 miles, crush it fine and wash it with great quanties of water, and all for a cost ranging from $1.27 to $1.50 per ton, seems remarkable. The normal price of copper seems to be about 13 cents a pound, at which price many mines can make a comfortable profit of about 4 cents a pound.

Mining, mechanical, hydraulic, electrical, civil metallurgical and marine engineering all have an interesting and extensive development here; in fact, the country depends solely on these interests. Yet there are other diverting interests for the non-technical visitor. The winter sports accompanying continued and reliable cold weather and a heavy snow fall are enjoyed as much here as any place in the country. Four or five feet of snow is not so bad when you get used to it, and the snow-shoeing, skii-running and skating are enjoyed by many. Just now a $40,000 ice rink holds enthusiastic crowds who uphold the Portage Lake hockey team as United States champions. The game of hockey is a development of the old-fashioned "shinney" played on the ice, and is one of the finest of games for the spectator as well as the player. The fall brings good hunting of partridge and deer, and the streams still have a few trout.

A great variety of nationalities are represented among the mine workers, who are well housed, industrious, and generally well contented.

THE TURBINE CENTRIFUGAL PUMP.

(Communication to THE TECHNIC.)

Editor of The Technic:

In William D. Ingle's article on Electrical Coal Mining Machinery which appeared in the January TECHNIC, the statement was made that "centrifugal pumps cannot be used to pump against very high heads." It is further stated that "they are inefficient for heads greater than 50′ or 60′, and have a maximum efficiency against heads in the vicinity of 20′."

Up to a comparatively recent date these statements were true, but recently a new type of centrifugal has been put on the market. This is the turbine centrifugal pump. It is revolutionizing the ideas of the engineering world in regard to the value of centrifugal pumps.

The turbine water wheel, with its high effici-

ency, suggested, in a measure, the idea of the turbine centrifugal pump. The reversed water wheel, with a few necessary structural changes, was the basis of the present pump.

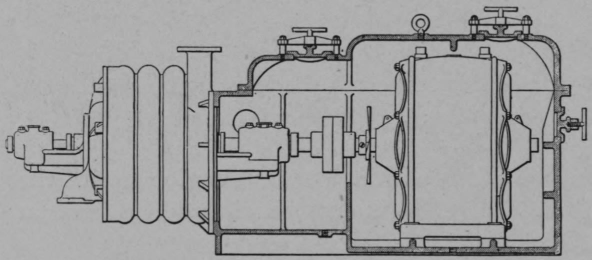
The turbine pump differs from the ordinary centrifugal pump in the introduction of a "distributing ring," which corresponds to the inlet openings of an inward flow turbine water wheel.

A single turbine pump, of suitable size, will deliver any required quantity of water against any head up to 150′, with an efficiency of 70% to 80%.

When it is desired to pump against a head greater than 150′ two turbines are used. They are compactly arranged in the same case so that the first pumps directly into the second. Such an arrangement is known as a two-stage machine, and will pump with its maximum efficiency against heads from 150′ to 300′. For still greater heads this same process of adding more turbines on the same shaft in tandem, goes on until we have four, five and six-stage machines.

For example, a 20″ four-stage machine would deliver 12,000 gallons per minute against a head of 600′ with an efficiency of about 75%. The accompanying photograph shows the general appearance of such a four-stage machine.

Motors may be enclosed as is shown in Figure 2, when used in mines or other places where there is liability of damage by water.



SECTION OF A WORTHINGTON MULTI-STAGE TURBINE CENTRIFUGAL PUMP, Direct Connected to an Encased Motor; for Mine Service.

FIG. 2

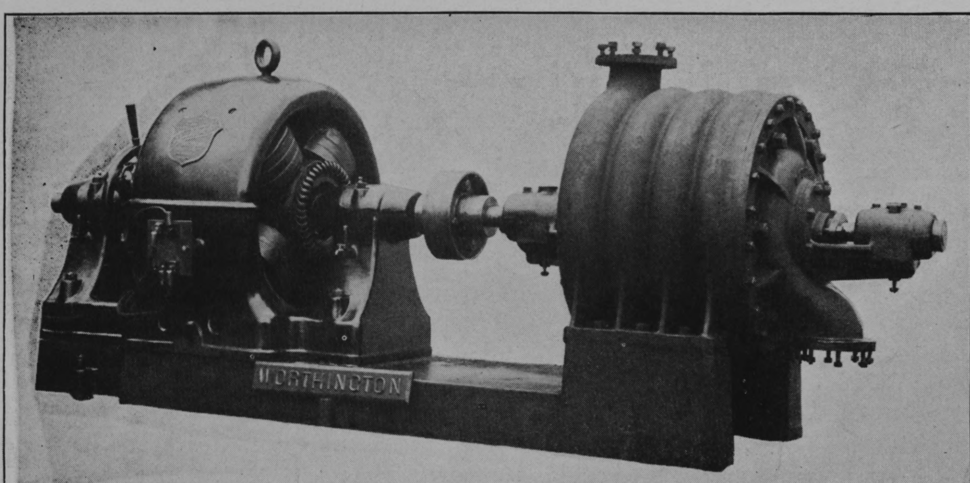
Now that the efficiency and capacity of the centrifugal pump has been so materially increased, many new uses suggest themselves to the engineer.

They are now used successfully for mining, dredging, filling house tanks, furnishing power for elevators, circulating cooling water for and removing the condensed steam from surface condensers, etc.

The pumps described above are built by Henry R. Worthington, New York. They also make several other types of centrifugal pumps, and are prepared to furnish them for any requirements.

Yours truly,

FRANK A. WHITTEN, '98.



ALUMNI NOTES.

I. M. L. Werk, '96, is with the Osborne Petroleum Co. at Glasgo, Ky.

Abe Balsey, '91, is electrical engineer with the Georgia Railway and Electric Co. at Atlanta, Ga.

E. E. King, '01, is assistant engineer with the C. R. I. & P. R. R. engineering department at Chicago, Ill.

R. N. Miller, '01, is taking a course in law at Harvard University.

J. M. Lansden, '98, manager of the Birmingham Electric Co. at Birmingham, Ala., expects to move his factory to New York City. He is now in New York testing machines in connection with Edison's new storage battery.

Leslie Helmer, '01, Superintendent Cumberland Black Plate Mills, slipped and fell on the ice Feb. 22. The ligaments of his right leg were torn so that it had to be put in a plaster cast, and he will not be able to return to work for several weeks.

Mr. William G. Davis, '99, is now selling engineer for the Electric Storage Battery Co., Philadelphia, Pa.

A. L. Robinson, '95, is now at Princeton, Ind. He is Master Mechanic of the St. Louis and Louisville lines of the Southern R. R.

F. W. Schneider, '98, is electrical inspector in New York City, in the department of water supply, gas, and electricity.

H. W. Uhl, '02, is at present at Philadelphia inspecting new engines that are to be received by the Union Pacific and Oregon Short Line R.R. He is at the Baldwin Locomotive Works, and will be there until some time in March.

H. W. Palmer, '03, has been transferred from the Western Electric Co. at Chicago to its engineering department in New York City.

H. J. McDargh, '96, is now a member of the firm, Folsom & McDargh, Consulting, Civil and Hydraulic Engineers at Dayton, Ohio.

Carl D. Fischer, Jr., '03, spent the last week of March visiting his friends in Terre Haute.

R. L. Wilson, Rose Polytechnic '92, who spent a number of years in the works of the Electric Company as student, inspector and tester, and who recently had charge of the 5000 kw generators of the Manhattan Elevated Railway and other apparatus in New York, was made Superintendent of Construction (vice W. K. Dunlap) on Feb. 1.—[*The Electric Club Journal*.

Fifteen members of the Kansas City Section of the American Chemical Society met at the Midland hotel last night. Out of town guests were: Prof. L. E. Sayre and Prof. E. C. Bartold of Lawrence, Kas.; W. B. Berry and O. C. Steinmeyer of Topeka.

R. C. Warren, assistant of Dr. Robert Moechel, city chemist, read a paper on "The Dry Qualitative Analysis of Minerals," which was generally discussed.—[*Kansas City Star*.

Y. M. C. A.

Friday evening Feb. 12, A. W. Hanson, State Secretary of College Y.M.C.A., and T. G. Pierson Rose '97 visited the Association here. Mr. Pierson made a few remarks on the early work at Rose. He was one of the men who fostered the Rose Tech Y.M.C.A., in its infancy.

Mr. Hanson gave a very interesting and instructive talk. He expressed himself as well pleased with the Association work here and gave many valuable suggestions for its advancement.

Mr. Pierson has promised to visit us again this year. Those who do not hear him will miss one of the best meetings of the year. He is one of several Poly graduates who are influential in Y. M.C.A. work. That his ability is recognized is shown by the fact that he has been elected a member of the State Executive Committee and was sent as a delegate to the last "Worlds Christian Conference," held in Germany.

DISTILLERIES

By J. HARRY BARBAZETTE, '04.

ALTHOUGH the process of separating spirits from corn mash is simple, the operation of the still as carried on under the direction of the government affords some interest. The principal liquor producer in these districts is a mixture of corn, rye and barley, while in many places sugar, starch and molasses are used.

Starting with the grain as it arrives in cars, it is first unloaded into separate bins from which the mixture mentioned above is made up. This mixture, consisting of about 80% corn, is elevated by means of a chain of buckets to a set of rolls where it is finely ground. It is then conveyed to a store room, called the "meal floor," which is directly above large bins known as "hoppers" in which it is weighed by government men. These weights serve as a check on those taken while the grain was still in the car, and stand as proof that no grain has reached the cookers but that under the care of the revenue men. The cookers are large cylindrical tanks in which the meal and water are mixed and cooked for about 40 minutes. After the cooker has been charged live steam is turned into it under a pressure of 70 pounds and the corresponding temperature 316° F. To remove this pressure vacuum pumps are used until the remaining pressure can be turned into the air without carrying any mash with it. The cookers when under atmospheric pressure are emptied into cisterns termed "mash cisterns" which serve to prevent the delay of the cookers. From the mash cistern the mash is pumped into tubsfor fermentation, and on the way is cooled by water flowing in the opposite direction through a water jacket, consisting of a larger sized pipe, and by this means the temperature is reduced from 316° F. to 70° F., at which it enters the fermenting tubs. Yeast is mixed with the mash in the fermenting tubs, and fermentation lasts for not more than 72 hours. The law requires the emptying of the tubs at the end of this time. When the house is not running at its full capacity only enough tubs are left unsealed to make the run agreed upon and to compel the distiller to comply with the law he is required to give $100,000 bond annually.

The quality of the yeast used greatly effects the per cent. of spirit obtained, and for this reason great care is used in its preparation. Although the general methods used are pretty well known, the particular turns of each yeast maker which make his yeast the best are carefully guarded.

The mash, after fermentation, is called "beer" and is dropped into a cistern, from which it is pumped slowly through the "still." As mentioned, there are two cisterns and in each of these as well as in the cookers there are revolving rakes, the object being to prevent the mash settling and choking up the pumps. The beer still is simply a vertical cylindrical tank about five feet in di-

ameter and 50 or 60 feet high, with perforated plates about 18 inches apart, through which the beer drops, meeting live steam, the temperature of which is high enough to evaporate the liquor in the beer and carry it fromthe still to a condenser. The liquor in this crude state is called "high wine" and is carried to a receiving tank, but on the way it passes through a glass box from which the temperature and specific gravity can be taken, which give the strength from prepared tables. The beer from which the high wine is taken collects in the bottom of the still and liberates itself automatically, and is used as stock feed directly or is dried for shipment. After the high wine has been obtained the process is completed by purifying these wines. The wine is forced through packed charcoal after leaving the receiving tank and all solid matter is removed. Instead of mixing live steam directly with the wine for the last distillation, the wine is run into a kettle which is supplied with copper coils through which the steam passes, and by this means the former is evaporated and held under a pressure of about three pounds, this being enough to carry the vapor through the "spirit column" as it is termed. In the spirit column the plates forming the chambers differ from those in the beer still in that they have only one passage for the vapor, and that is through a short tube in the center. The tops of these short pipes have hoods over them which turn the vapor down against the bottom of the chamber where impurities condense, while the temperature of the vapor is enough to hold the purer spirits, and carry it through all the chambers of the spirit column to a condenser. The first and last parts of the vapor carry some impurities over, so they are drawn off and only the central part is used for the better grades of spirits. To note the changes in the spirits they are run through a glass box, after being condensed, where, as in the case of the high wine, the proof can be found by noting the specific gravity and temperature, and when the degree of purity desired has been reached the spirits are run to the "cistern room" where they are gauged, drawn off into barrels and deposited in the bonded warehouse.

To prevent any smuggling of goods from the pipes carrying mash or spirits the government seals every joint and locks all valves, and all storerooms for liquor are locked. The keys are held by a storekeeper, who has a list of interesting laws for the several keys. Laws having special reference to distilleries are collected and printed in book form at Washington and sent to every revenue man as a reference. There are a few of these laws which sometimes cause a great deal of inconvenience, such as one requiring the cookers to be closed Saturday night promptly at at 11 o'clock, and another permitting the warehouse to be open only from sunrise to sunset.

For every gallon of "proof spirits" as defined by law there is a tax of $1.10. The definition of proof spirit is "that alcoholic liquor which contains one-half by volume alcohol, and has a specific gravity of .7939 at 60° F." Proof spirit is classed as 100 proof goods, and a gallon of pure spirit would be 200 proof goods, and the tax would be double that of proof spirit. After the spirit has been drawn into barrels for shipment and tested, a record is made of the proof and the amount in each barrel, and stamps are bought to correspond. Special agents often appear unexpectedly to check the goods with the stamps or to rally his forces. For his benefit the pipes in the distillery have to be painted to signify what they carry, as; white for steam, black for spirits, red for mash, etc., making it easy to follow any line of pipe. It is easy to understand why the goverment watches its interests so closely when they amount to from $400,000 to $1,000,000 per month in each distillery of the size of those in Terre Haute.

Spirits, alcohol and rye, are produced by distilleries directly, while whiskey and gin are compounded spirits. Spirit, as described, is the purest part of the liquor obtained, and alcohol is simply spirits containing some impurities. Rye whiskey is a liquor obtained from either a mixture of rye and other small grains, or from rye

alone, and the process is similar to that used to produce spirits. Gin is made by flavoring spirits of 100 proof with juniper berries. Spirit of 103 proof which has been allowed to stand in charred barrels for several years makes the best whiskey, but most of the whiskey on the market is a compound of spirit, with oils and other substances which have nearly the same effect upon the spirit as two years of age. Whiskey produced by ageing in charred barrels and that made by compounding are mixed and produce a ''blend'' which is the mixture generally found on the market.

The compounding houses take the principal part of the liquor produced by distilleries, but large quantities go to manufactories, hospitals, laboratories, etc.

After a run has been completed, there is a somewhat important by-product known as fusil oil which remains in the still. To remove this from the still steam is passed in under a higher pressure that that used in separating the spirit, so that this oil is taken up by the steam and carried away from the still to a condenser.

CAMERA CLUB.

The Camera Club held a very interesting meeting on Thursday night, Feb. 18, at the studio of Mr. George Holloway of this city. Mr. Holloway gave a very instructive and practical lecture on several phases of amateur photography, and made especial reference to flash light work. At the end of his lecture, he gave a flash light demonstration, taking a large flash light photo of one of the members. The remainder of the evening was spent in discussion of the work of the club, and plans were made for future photograpic excursions to be made by the club around the outskirts of the city. The following were present: Barker, Klenk, C. Wischmeyer, Noelke, Amorin, H. Wischmeyer, W. E. Johnson, O. L. Wood, Demmitt, Kelsall, Wilms, Heniken, Addison Lee, Hahn, Nantz, R. W. Hill. Mr. Holloway has kindly consented to give another talk before the club in the future, and will accompany the club on their photographic excursions this spring.

The pictures placed in the case in September have been replaced by others, and new developer has been placed in the dark-room.

MANDOLIN CLUB.

At a recent meeting of the Mandolin and Guitar Club, Mr. James Gibbons of Terre Haute was admitted as a member. Mr. Gibbons is well known in Terre Haute. He is at present a student in the High School but will enter Rose with the class of '08. His admittance to the club was timely, on account of the losses which the club has recently sustained in the departures of Beattie, '06 and Parker, '07.

The weekly practice meetings are still being held every Thursday, and instructor Brandenberg promises some catchy selections for the next concert.

''Jocko'' the club's Mascot has recently been presented with a new suit of clothes, and also a miniature Mandolin upon which he is learning to play. It is rumored that he is making great progress in this direction and will probably be ready to make his appearance with the club at the next concert.

ROSE SYMPHONY CLUB.

Rose Symphony Club will give a concert for the benefit of the *Modulus* the latter part of March.

Mr. Wells, '05, has recently joined the Glee Club as a second tenor.

TELEGRAPH COMPANY.

The Telegraph Company has finally succeeded in getting the circuit closed and getting current.

Thirty-five gravity cells supply the current. One thing quite noticeable is that the current is much stronger at night, — probably due to induction from the arc light circuit.

R. P. I., 52; I. S. N., 14.

IN the city league series for the *Star* trophy cup the basket ball team added another game to its winning column, by easily defeating the State Normal five. From the start the Normalites were never in the running, consequently making the game appear very slow to the spectators. The Poly team played one of the best games it has put up this season, playing rings all around their opponents, both in team work and goal throwing. Trueblood's goal throwing was one of the features of the game, getting goals, as he did, from almost any position. Johnson also played a star game at guard, besides getting five field goals.

R. P. I., 60; CO. B, 8.

The R. P. I. second team easily defeated Co. B, in the city league series, in a highly entertaining, if not very scientific game of basketball, by the score of 60 to 8. Both sides played in bunches and fell over each other in their attempts to get the ball. Owing to Co. B not having a full team, four men played on a side during the first half. Wischmeyer's goal throwing was the feature of the game, getting 10 field goals in the first half and 4 in the second, although B. Shickel was a close second in the first half, with 6 field goals to his credit. Glover at guard also did good work, guarding his man well, besides getting 6 field goals. The first half ended with a score of 40 to 4 in favor of R. P. I.

In the second half Co. B opened up with a burst of speed that almost ran the second team off their feet, but they could not keep up the pace and allowed 9 more field goals before time was called. Monninger played the best game for Co. B, besides getting a goal from the center of the floor.

The second team lined up as follows:

	FIRST HALF.			SECOND HALF.		
NAME.	Fouls.	Foul Goals.	Field Goals.	Fouls.	Foul Goals.	Field Goals
Wischmeyer, f., . . .	0	0	10	1	1	4
B. Shickel, f., ...	0	0	6	0	0	1
H. Shickel, c., ...	0	0	1	1	0	1
Glover, g., ...	0	0	3	0	0	3
Snider, g., ...	—	—	—	1	0	0
Awarded by referee .					1	
Total	0	0	20	3	2	9

Final score—R. P. I., 60; Co. B, 8.
Referee—McCormick.

PURDUE vs. ROSE POLYTECHNIC.

(C. W.)

On the evening of February 29, our basketball team met the Purdue squad, and was defeated by the score of 35 to 27. The game was fast from start to finish, and in team work and passing our boys seemed to have the best of it throughout. Their chief trouble was their inability to hit the baskets, which differed markedly from those in our own gymnasium.

The first point scored was a foul goal thrown by Thurman. During the greater part of the

first half, Rose led by several points, but just before the end of the half, Purdue took a brace and gained a lead of six points.

In the second half Rose once more caught up, and gained a lead of two points. During the last eight minutes of play, Purdue again overtook us, and held the lead until the end of the game.

For Rose, Johnson played the star game, allowing his man but one goal, and getting one point for being fouled while throwing at goal. Trueblood, as usual, threw several pretty goals, getting one in on the first half while two men were guarding him. Thurman had his eye peeled for foul goals, throwing seven out of about ten chances, amid the yelling and jeering of the Purdue rooters.

The summary of the game is as follows :

PURDUE.

	FIRST HALF.		SECOND HALF.	
	Goals.	Fouls.	Goals.	Fouls.
Peck, f., ...	1	2	0	0
Glover. f., ...	3	0	5	1
Mueller, c., ...	0	0	1	0
Cadwell, g., ...	4	3	2	1
Holdson, g., ...	0	1	1	1

ROSE.

	FIRST HALF.		SECOND HALF.	
	Goals.	Fouls.	Goals.	Fouls.
Thurman, f., ...	1 field, 4 foul	0	2 field, 3 foul	1
Daily, f., ...	1	0	1	0
Trueblood, c., ...	1	0	3	1
Shickel, g., ...	0	1	0	0
Johnson, g., ...	0	1	0	1

Referee—Walters, Crawfordsville.
Umpire—Kayler, Purdue.
Timers—Glover, Rose and Smith, Purdue.

WABASH, 26 ; R. P. I., 24.

In one of the bitterest fought games of the year, Wabash came out victorious by the score of 26 to 24. Incidentally it was one of the roughest games played this season against the local team, and most of the credit goes to Williams, guard of Wabash, who said after the game that tripping and holding were the fine points of his game.

It was anybody's game, first one side scoring then the other. Wabash started out as if they intended making a runaway game of it, scoring 7 points before the Poly five had settled down to business. After that it wasn't so easy, the score gradually evening up until at the end of the half the score stood, Rose 11, Wabash 9. In the second half, Burgess was substituted for Marshall and he made good from the start, scoring two field goals in quick succession. His playing, coupled with Lehman's foul goal throwing, proved to be too great a handicap to overcome, and Wabash quickly ran the score up until at the end of the game the score stood with Wabash two points to the good.

Summary :

WABASH.

	FIRST HALF.			SECOND HALF.		
NAME.	Fouls.	Foul Goals.	Field Goals.	Fouls.	Foul Goals.	Field Goals.
Lehman, l. f., ...	1	4	0	0	4	1
Loop, r. f., ...	2	0	1	0	0	2
Marshall, c., ...	6	0	0	0	0	1
Burgess, c., ...	—	—	—	0	0	2
Williams, l. g., . . .	2	0	0	5	0	0
Henry, r. g., ...	1	0	1	1	0	0
Awarded by referee,		1			1	
Total, ...	12	5	2	6	5	6

ROSE.

	FIRST HALF.			SECOND HALF.		
NAME.	Fouls.	Foul Goals.	Field Goals.	Fouls.	Foul Goals.	Field Goals.
Thurman, l. f., . . .	1	0	0	2	6	2
Daily, r. f., ...	2	0	1	0	0	0
Trueblood, c., ...	3	5	2	3	0	1
Johnson, l. g., ...	1	0	0	0	0	0
Barbazette, r. g., . .	0	0	0	0	0	0
Awarded by referee,					1	
Total, ...	7	5	3	5	7	3

Final score—Wabash, 26 ; R. P. I., 24.
Referee—W. R. Porter, Wabash College.
Umpire—Ira Kisner, Terre Haute.

CRAWFORDSVILLE BUSINESS GOLLEGE 19, VS. R. P. I. 29.

The R. P. I. team easily defeated the C. B. C. team on February 20 in a fairly rough and exciting game. Time was taken out only once or twice due to a Crawfordsville team man being injured, and especially in the second half when Fink collided with Trueblood's shoulder and had to be carried from the floor, Fyffe taking his place at center.

The stars of the game were Thurman and Johnson, Thurman throwing 5 field goals and 10 foul goals out of 13 trials, and Johnson managed to throw 3 field goals, one of which the referee refused to allow, saying he had "dribbled" the ball before throwing.

Reiman played the game for his team, getting 4 field goals and 4 foul goals out of 10 shots at the basket.

The work of Referee McClamrock was the best seen here this season, and it certainly was a relief to everybody to have such an official after the wretched work of such men as Wabash and Purdue brought with them.

Summary :

CRAWFORDSVILLE BUSINESS COLLEGE.

NAME.	FIRST HALF. Fouls.	Foul Goals.	Field Goals.	SECOND HALF. Fouls.	Foul Goals.	Field Goals.
Reiman, l. f.,	0	2	2	1	2	2
Brosius, r. f.,	0	0	1	0	0	0
Fink, c.,	0	0	0	—	—	—
Fyffe, c.,	—	—	—	1	0	0
Watson, l. g.,	3	0	0	—	—	—
Ramsey, l. g.,	—	0	0	2	0	0
Crim, r. g.,	5	0	0	1	0	1
Awarded by referee,		1			2	
Total,	8	3	3	5	4	3

ROSE.

NAME.	FIRST HALF. Fouls.	Foul Goals.	Field Goals.	SECOND HALF. Fouls.	Foul Goals.	Field Goals.
Thurman, l. f.,	0	6	3	2	4	2
Shickel, r. f.,	1	0	0	0	0	0
Trueblood, c.,	2	0	2	0	0	0
Johnson, l. g.,	1	0	1	0	0	1
Barbazette, r. g.,	2	0	0	2	0	0
Awarded by referee,					1	
Total,	6	6	6	4	5	3

Final score—R. P. I., 29; C. B. C., 19.
Referee—McClamrock.
Umpire—Ira Kisner.

CITY LEAGUE STANDING.

	Won.	Lost.	Per Cent.
Y. M. C. A,	5	0	1000
R. P. I.,	4	1	.800
I. S. N.,	1	4	.200
Co. B.,	0	5	.000

BASEBALL.

Pitcher Ed Reed of the Hottentots has been engaged as coach for the baseball team this spring, and under his guidance we ought to have a better team than last year, and that is saying a good deal. The men have been practicing hard in the batting cage during the past winter, and within another week we ought to be out on the campus. There are nine men left from last year's team, and these, taken with the new men, ought to fill out the team and put it into first-class condition to win at least the majority of the games played.

INDIANA UNIVERSITY VS. ROSE.

(C. W.)

On first thought it would seem that the less said about this game, the better. Still, there are several facts which deserve to be mentioned.

Without wishing to make any excuses for our defeat, we feel that in justice to our men we must state that they were badly out of practice. This was due largely to the fact that many of the men have recitations until 5 o'clock several evenings each week. Indiana, on the other hand, played a clean, fast game, which would probably have won for them even had our men been in better condition.

Maxwell was Indiana's star player, getting thirteen field goals. It is rather difficult to say who did the best work for Rose. Thurman leads in number of points, while Daily secured the largest number of field goals. Thurman threw one very pretty goal from almost the center of the floor, bringing forth the well-merited applause of the I. U. rooters. Trueblood threw two goals from the field.

The full score is given below :

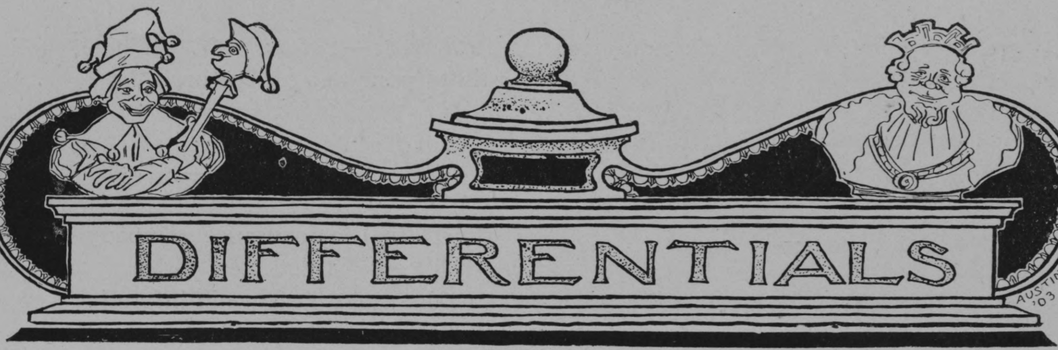
INDIANA.

	FIRST HALF. Goals.	Fouls.	SECOND HALF. Goals.	Fouls.
Penn, f.,	1	2	5	0
Harmison, f.,	1	1	5	0
Maxwell, c.,	6	1	7	0
Hubell, g.,	0	0	0	1
Taber, g.,	0	2	0	0

ROSE.

	FIRST HALF. Goals.	Fouls.	SECOND HALF. Goals.	Fouls.
Thurman, f.,	1	1	1	0
Daily, f.,	1	0	2	1
Trueblood, c.,	0	1	2	0
Johnson, g.,	0	0	0	1
Barbazette, g.,	0	0	0	1

Foul goals—Thurman, 5.
Referee—Hester.
Score—I. U., 50. Rose, 19.



This department of THE TECHNIC gratefully acknowledges the receipt of a number of good differentials which have been handed in during the past month.

You have written of Poly life
For the Poly student's mirth
"In jesting guise.—But ye are wise
And ye know what a jest is worth."

Now, boys, beware of the spring fever.

The Freshman class is certainly to be complimented on the fine showing that it made in the term examinations of last January. Only eight were lost through the "exams," whereas twice that number flunked out in the preceding Freshman class.

Freshman (making oxygen test):—"Professor, where do you keep the glowing splinters?"

Bauer was recently looking through the *Delineator*. There is a saying that present events foretell the future.

Thurman, in electrical lab.:—"Professor, have you a five horse-power armeter?"

Wicky, in scientific German: — "You must form the habit of guessing accurately."

Prof.:—"So far we have been dealing with the naked facts. We will now bring the matter to its close."

Atherton (having taken Leedy's stool):—"Now, Mr. Leedy, you are not capable of taking this stool from me, as you have not had the physical training which I have had."

T. L. Lee, of '06, has accepted a draughting position as assistant to "High-Pockets" Rumbly, '03.

Meyers (in Projective Geometry):—"Those rays aren't very enlightening."

McDaniel says he is going to celebrate St. Patrick's day.

Dame rumor reports the engagement of a prominent member of the class of 1905 to a young lady who has made Terre Haute her home for the past few years.

Wood, '07, was seen pouring distilled water over sheet aluminum to generate hydrogen.

Jenckes, '05, McDaniel, '07, Wickliffe, '07, and Miner, '07, have been initiated into Alpha Tau Omega.

Dr. White:—"Is water a mineral?"
Curry:—"No, sir, but I have heard of mineral water."

Gerst and Watt, both of '07, have become Sigma Nu's.

Demmitt:—A body starts with an acceleration of seven cubic centimeters."

Prof. (drawing figure for demonstration on board with colored crayons):—"Now, those of

you who are color blind, will unfortunately lose this demonstration."

Kiefer, '05, has been made a P. I. E. S.

Larkins has proved by calculus, that if l equals the length of a stick, then $\frac{l}{2}$ is equal to one-half of it.

First student:—"What is the passive voice?"

Second one:—"It's the voice you have to know in order to pass."—[*Ex.*

Atherton, '05:—"I made A and B in everything."

Wilkins, '06:—"Bosh, you are trying to stuff me."

Atherton:—"Very well, I advise you to believe it before the 'day of judgment.'"

Goodman, '05, tries to make himself out to be a bigger fool than he really is. So says Jojo.

Professor, in Physics to Freshie:—"If you don't take your feet off that bench in front of you, I will make you determine their coefficient of friction."

For his thesis, Hahn says he would like to make a test of the electric light plant over at St. Mary's. However, since he has suggested it, there are others.

A clever young man at the Sault
Bit off more than he safely could chault;
And the people all shout,
Now the cash has run out,
"We'll sault yoult, that is what we'll dault."
—[*Montreal Herald.*

It is a certainty that Peddle is Heick's wife. Peddle was seen to go to Heick and ask for money, which was reluctantly given him.

AT BARR'S.

Mrs. Barr:—"Barker, what will you have for dessert, peaches or bananas?"

Barker:—"The one you'll give me the most of."

Professor:—"Now, Mr. Shickel, tell that again to your weaker brethren."

One of Hath's equations:

Minus own=owe.

A certain life insurance company recently recently received this letter:

"I take great pleasure in informing you of the death of my husband who was insured in your company. Please send me the papers at once, so that I can prove that he is dead."

During the recent cold weather "Mexico" Wood was often seen cutting strange figures on the ice in the river bottoms.

Of all sad words
Of tongue or pen,
The saddest are these:
"I've flunked again."
—[*High School Times.*

Leedy:—"Caustics are formed by reflection and refraction of light. When the moon is the source we get Lunar Caustic."

Cargill, in Physics class:—"Professor, you are getting us all balled up."

Hath, sub two:—"If you are in danger of being hit by anything, build an air-castle and crawl into it."

Wilkins, '06 (giving definition of a cone):—"One of them things that's big at one end and little at the other."

Miller, '07, seeing "Grasshopper" Johnston buffing a Lincoln head, asked what kind of stone he was using.

Prof. Williams:—"You need not get angry."

White, '06:—"Oh, I am not angry—just a little 'sore.'"

Post has been elected Vice-President of the Freshman class, to succeed Kiely, who is preparing for West Point.

It is reported that a few Freshmen recently purchased tickets entitling them to attend "a series of tests to be made soon upon Prof. Howe's hydraulic machine."

Jojo (in Physical Lab.):—"Now, Mr. Larkins, suppose you work on the supposition that the longer you heat this water, the more steam you get."

Professor:—"Mr. Austin, I took off a little for saying something that you did not mean."

Austin:—Isn't what I said right?"

Professor:—Well, I'll give you zero for not knowing, then."

Fay:—"Smith got off something sharp the other day."

Geyer:—"What was it?"

Fay:—"A bent pin placed in his chair."

—[*Ex.*

Picture a brewery painted white,
Picture Rachel smoking a corncob pipe,
Picture his face—drawn tight,
Picture his stomach—so very light.

We were delighted to receive the following poem with the letter enclosed from one of our Alumni in Chicago. The poet does not disclose his identity, but from the trend of the lines we are able to judge that he is one of our graduates in that city who has found his life-pardner. Here's the letter and poem :

Editor of The Technic :

DEAR SIR :—The enclosed verses are submitted in the hope that you may be able to use them in the "Differential" page. They may serve as a warning to some prospective benedict.

Very truly yours,

AN OLD GRAD.

HER POINT OF VIEW.

"You ought to take an interest
In all my interests, dear."
Thus, to his charming little wife,
Once spoke an engineer.

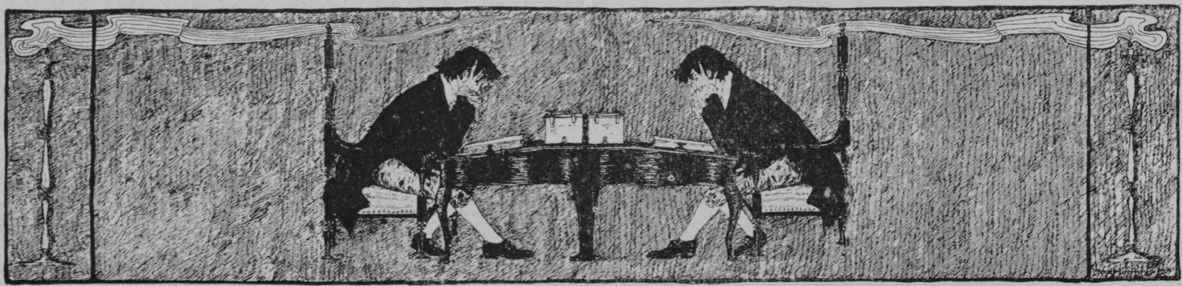
And forthwith he expounded
Much scientific lore
Which is to most girls, as you know,
An overwhelming bore.

His winsome wife smiled sweetly
When his discourse was through.
"Steam jackets! That reminds me
I need a jacket, too.

And speaking of the pumps, dear,
You need another pair
(Not steam ones. Patent leathers.)
Yours are not fit to wear.

You mentioned, too, a turbine,—
I'm glad you thought of that,
For now I'll buy a turban
When I select a hat.

I'm so glad," she continued,
"That you're an engineer.
I always take an interest
In all your interests, dear."



REVIEWS

Melting Out Frozen Water Pipes Electrically.

DURING the recent intense weather the method of thawing out frozen water pipes electrically was undertaken successfully at Altoona, Pa. Mr. E. B. Greene, the well-known superintendent of the Edison Electric Illuminating Company of that city, who has been conducting this still novel and interesting work, writes as follows concerning practical results:

We use for this purpose alternating current of low voltage, the maximum voltage not being over 50. The method of doing this, as you know, originated with Messrs. Jackson & Wood about the year 1900, so you will appreciate it is not new with us. We use a 25-kw transformer wound for 50 volts, using an amperemeter to know what quantity of current we are using, and reduce the voltage with a water rheostat, using a common table salt to impart the necessary conductivity.

The transformer, water rheostat and instruments are assembled in a box which is hauled out to the place desired to use, when the transformer is connected up to run as in ordinary methods of lighting, using the water rheostat on the primary side of the transformer (as this requires a very much smaller vessel for the water rheostat). The secondary or low voltage cables are connected directly to the spigot or to the pipe inside the building, the other one being connected to a fire plug, or, if more convenient, to the pipe in an adjoining house, which then completes the circuit on the iron pipe for the low potential.

We have thawed 250 ft. of one-inch iron pipe in twenty minutes actual time of current on, using between 18 and 20 kw. In smaller services, say ¾-in., and on 30 or 40 ft., we have thawed out in from five to eight minutes, using 11 to 15 kw. The appartus is very small and it is quite a convenience to people to have water, when their pipes are frozen, in two or three hours after asking to have the apparatus connected up. There is, of course, very little business in the sale of current in connection with the above, but the advertisement we get from being able to help out people who don't have water we think will repay us amply for the trouble and the expense entailed.

As you, no doubt, can see from the above the cost of sending out the transformer, the time of the men connecting up and disconnecting, and the draying charges would leave very small margin unless you would charge an excessive price, which we don't believe it pays us to do. The cost varies very much. The cheapest job, which was near the station, was $2.50; the most expensive one was $9.50; yet the amount of current used is a very small amount as compared with the charges for labor and drayage.—[*Electrical World and Engineer.*

The Theory of Aluminum Electrolytic Rectifier.

WITHIN the last few years much interest has been displayed in the aluminum-carbon electrolytic cell, since experiments have been made looking towards making the apparatus industrially available as a rectifier. It is known that when a plate of aluminum is opposed to a plate of carbon in a suitable electrolyte, the cell so formed offers but little obstruction to an electric current entering at the cabon and leaving at the aluminum; that is to say, when the aluminum is the cathode. On the contrary, when the current is reversed and the aluminum is made the anode, the cell offers a very marked obstruction and practically shuts off the current, if the voltage does not exceed 20 or more volts. Consequently, when such a cell, or a battery of such cells, is inserted in the path of an alternating current, the semi-waves directed towards the aluminum go through with but little drop of pressure, or waste of power, while the intervening and oppositely directed semi-waves are automatically shut off, to a greater or less extent. In other words, the alternating current has become converted into what is substantially a unidirectional pulsating current. Such an arrangement could, of course, only utilize half the alternating-current impulses. But by the use of divided circuits or branches, with a pair of such batteries, all positive waves could be utilized unidirectionally in one branch, and all negative waves unidirectionally in the other, the two could coact, in most cases, to produce a unitary result, equivalent to complete rectification of the altnernating current. The apparatus, however, has not yet come into practical use, mainly owing to relatively large losses of energy in the electric walves. That is to

say, the current is not instantly shut off, as soon as the aluminum turns anode, but a certain amount has to go through, in order to shut off the rest, like the "wire-drawing" in an imperfectly adjusted steam valve. If this wire-drawing loss of power could be eliminated, the cell might be capable of some practical service on alternating-current circuits.—[*Electrical World and Engineer.*

Bronze for Heavy Guns.

AUSTRIA is now the only nation using bronze as the material for its heavy guns, and a circular recently put out by the Austrian War Ministry indicates that it is the intention of that government to retain it. It is claimed in the pamphlet referred to that this bronze, forged according to a secret process, is equal to nickel steel, and that the cost of the inner tube is three-fifths less than that of the steel tube. Another advantage is that an injured bronze gun can have a new jacket fitted to it, which is impossible with a steel one. The Austro-Hungarian artillery has always used bronze for their gun material. In that service there have for decades been officers who have directed their attention to the improvement of this metal. The invention of nickel steel and the general advance in steel manufacture are certainly important, but the same period has been utilized in Austria for the perfecting of bronze. Uchatius, who in the seventies discovered a special process for forging bronze, also found that good homogeneous bronze could be hammered in a hot or cold state, and therefore can be improved in quality. The present director of the Vienna Arsenal also obtained very favorable results in forging this metal, producing a kind of bronze not surpassed, it is claimed, by the best cannon steel, through a combination of metals, carefully alloying and judicious rolling.—[*American Machinist.*

A New Metal—Nodium.

UNITED States Consul-General Guenther sends from Frankfort, Germany, the following:

A new metal which is similar to aluminum, but still of lesser weight, has been discovered by the French engineer, Albert Nodon, and called "nodium," after him. It is manufactured by an electric process. In color, luster, and structure it is almost exactly like steel. Its specific weight when molten is only 2.4. Its resistance against breaking is given as about 20 pounds per square of 0.04 inch. Its constancy in the air is higher than that of aluminum. Its ductility is between 6 to 8 inches; the malleability can be compared to that of bronze. It melts at about 600 degrees. It is suitable for being cast into forms. The conductibility for the electric current is as high as that of copper of equal weight. If natural power, especially water power, can be used for its manufacture, the cost in round figures is about 15 cents per pound. The inventor expects numerous uses of nodium in the near future, especially for electric wires and cables, for light but strong parts of motor cars, torpedo boats, men-of-war, street cars, military outfits, air ships, etc., and for castings in place of bronze, German silver and similar metals. Nothing definite has yet been communicated as to the chemical composition of nodium nor as to the mode of its manufacture.—[*American Machinist.*

Distributing Illuminating Gas Under High Pressure.

ON account of the heavy cost of mains when illuminating gas is distributed at ordinary pressures, especially to outlying and suburban districts of a city, plans are being matured in St. Louis for the use of higher pressures in the mains with reducing valves at the suburban distributing centers. Two systems will be used, in one of which the pressure in the mains will be about five pounds per square inch, this pressure being adopted in order to use cast-iron mains. In the high-pressure system, pressures of 20 to 80 pounds will be used with pipes having screwed joints. The machinery for the first-named system will consist of Connersville blowers connected direct to 300 horse-power Westinghouse gas engines fitted with pressure governors to adjust the speed in proportion to the demand for gas. Of the machinery for the high-pressure system, we have no information.—[*American Machinist.*

A MODERATE estimate shows that at least 50 per cent. of the gas sold to-day is used for other purposes than lighting. The light-giving power of the gas burnt as a luminous flame has become of little or no importance by the introduction of the incandescent mantle, which enables 5 feet of gas, converted to a non-luminous flame by the Bunsen burner, to produce a light equal to about 100 candles against the 12 or 14 candles of thirty or forty years ago.—[*The Engineer.*