ing purposes. The discharge, too, is far more powerful. My coil, when connected with a condenser of six one-gallon Leyden jars, the primary being fed with a 52-volt alternating current from a Thomson-Houston transformer, produces a discharge the roar of which is so terrific that it is unpleasant to remain for any length of time in its vicinity. The power of the discharge can, however, be decreased to any extent if the nerves of the experimenter require it. Such a coil can be constructed at an outlay of about $20, and can be operated for a few cents an hour.

The core consists of a bundle of soft iron wires 15 inches long by 2 inches in diameter. Great care should be exercised to obtain wire of a suitable quality. Ordinary so-called soft iron wire furnished by hardware dealers is wholly unsuitable. The best material is known as "core wire," and can be obtained from any large dealer in electrical goods. Around this core are wound two layers of No. 6 double-covered magnet wire, the core being first wrapped with one or two thicknesses of thick paper to prevent possible short-circuiting. It is not necessary to paraffin or varnish these layers, as there is but little tendency toward internal sparking in a coil of this description.

The form of the secondary coil is quite different from that generally adopted by makers of induction coils. Instead of being spread out over the whole length of the primary, it is concentrated in the center, in order to obviate the effect of the ends of the primary. It is wound on a double spool 14 inches in diameter and 6 inches in width. This spool is made in two sections, as follows: Four wheels, 14 inches in diameter, are cut out of half-inch well seasoned wood, and a hole 3¼ inches in diameter bored in the center of each. Two hollow wooden cylinders should then be turned, measuring 3 inches in length by 3¼ inches external diameter and 2¾ inches internal diameter.

The wooden wheels will fit on to the cylinders, forming two spools, each having a space two inches in width for the winding of the secondary coil. It may be necessary to depart slightly from these dimensions, as the internal diameter of the cylinders should be large enough to allow of their slipping over the primary coil. The wooden pieces should be thoroughly boiled in paraffin until they cease to give off bubbles of steam. The wheels may then be glued securely to the wooden cylinders, taking care to have them as nearly parallel as possible. The two actions of the secondary should be wound separately with No. 30 cotton-covered magnet wire, of which 15 pounds will be needed. The winding can best be accomplished by fitting a solid wooden cylinder within the hollow one and mounting the whole affair on a spindle turned by a crank or in a lathe. The end of the wire should be passed out through a small hole in the wooden disk close to the cylinder, and the wire then wound evenly and closely across the spool. After the first layer is wound it is brushed over with melted paraffin, which should be hot enough to thoroughly interpenetrate the strands. A strip of thick brown paper which has been previously soaked in melted paraffin is then fitted neatly over the layer and the ends fastened together with hot paraffin. The paper should come close against the sides of the spool and the junction should be painted with paraffin to insure perfect insulation. The next layer is then wound and treated in the same way. It is difficult at first to wind the wire evenly and closely, but with a little practice the wire may be made to guide itself. If the turning is done by hand it is better to have some one to work the crank, and give one's entire attention to guiding the wire. The winding should proceed, each layer being brushed with hot paraffin as described, and insulated from its neighbor by the paraffined paper, until the wire is within three-quarters of an inch of the rim of the spool. If a break occurs in the wire, it should be neatly soldered and carefully insulated.

The second spool should be wound in an opposite direction from the first, so that when the two spools are placed side by side and the *internal* terminals joined, the direction of the wire will be the same in each. The exterior terminals should be fastened to binding posts and the interior soldered or twisted together, and the spools should then be fastened together by driving three-quarter inch brass screws through the rims of the two inside wheels. Care should be taken to have them fitted exactly, so that the primary coil may pass easily through the center of the bobbin. A fine finish may be given to the coil by ebonizing the woodwork and covering each section of the secondary with a strip of thin hard rubber. If there is any spare room between the primary and secondary, it may be filled by covering the primary with black silk or a thin tube of hard rubber. A covering of some sort is necessary to prevent the heavy secondary coil from abrading the insulation of the primary. The coil is now finished. No interrupter, commutator or condenser is required.

The primary wire should be fed with an alternating current of about 52 volts, such as is furnished by the Thomson-Houston incandescent system. As soon as the current is turned on the coil will hum, and care must be exercised to keep away from the secondary terminals. The discharge differs curiously from the ordinary Ruhmkorff. Only a very small static spark can be drawn from a single terminal, by approaching the finger to it, and no discharge takes place between them until they are brought within a quarter of an inch of each other, and it is best shown between two carbon points. As soon as they are brought within striking distance a small arc will be established, and they may then be separated to a distance varying from two to four inches, according to the strength of the current in the primary. The arc emits but little light, and bends upward in a graceful curve with the current of hot air.

It is with the Leyden battery that the tremendous power of the coil can be shown. From six to ten gallon jars, or more of a smaller size, should be connected with the terminals of the coil, as indicated in the diagram; all the inner coatings being connected with one terminal, and the outer with the other.

The discharge now consists of a torrent of thick blue sparks, which gives rise to a most deafening sound that is a combination of a hiss and a roar. The power of this discharge may be still further increased by putting into the circuit a coil of high resistance, as shown in the diagram, such as the secondary of a medium sized Ruhmkorff, which adds to the capacity of the circuit. Great care should be taken not to allow the current to pass through the body, as the effects are very painful, if not dangerous. I have accidentally taken the current from my coil when running at about one-fifth of its full capacity, and do not care to repeat the experience. There was an awful wrench, followed by a sensation as of just awakening from an anæsthetic sleep. I imagine that the current produced complete unconsciousness for a fraction of a second, though I did not fall.

The powerful discharge from the coil used in connection with the Leyden jars is most admirably suited for obtaining metallic spectra, either for photographic or visual purposes. If the metal is easily volatilized, or in the form of a chloride, the arc obtained by using the coil alone will show the spectrum of the metal entirely devoid of the air lines which are always present when the bright spark from the condenser is used. The coil may be also used to advantage for operating large-sized vacuum tubes. A very pretty effect may be produced by allowing the discharge to pass between two carbon points in a low vacuum under the receiver of an air pump. If the points are first brought close together, in order to start the current, they may be separated as far apart as the dimensions of the receiver will allow, and there will be formed a beautiful arc of purple fire, a foot or more in length, surrounded by a wide aureole of a pale yellow-green color, and the receiver itself will shine with a pale blue phosphorescent light.

If the current feeding the primary is furnished by a transformer, the incandescent lights supplied by the transformer will be greatly dimmed while the coil is in action. This is because the primary acts on the transformer as a choking coil, lowering its electromotive force. If this is an inconvenience, as may often be the case, it may be remedied by increasing the self-induction of the primary. This may be done by winding a hundred or two turns of No. 15 double-covered wire into a coil three or four inches in diameter, and slipping it over one end of the primary in such a manner that, when placed in circuit with the primary, the direction of the current will be the same in the two coils. This will decrease the capacity of the coil to a great extent, but the discharge will be as powerful a one as it is comfortable to work with, when the jars are in circuit. It is a good plan to make a strong wooden stand for the coil, which will support the primary on each side of the secondary; and, if it is necessary to move the instrument about much, it is desirable to mount it on chair casters, as it weighs nearly 50 pounds. The core weighs about 10, the primary 9, the secondary 15, the wood and paper about 4, and 8 or 9 pounds of paraffin will be used in saturating the wood and paper and insulating the layers of the secondary.

What the physiological effect would be if the full current were taken I do not know. I doubt if it would be fatal, but it would be a very hard blow. Possibly coils of this description, built on a large scale, would be convenient for electrocutions.

THE GARIBALDI BRIDGE OVER THE RIVER TIBER AT ROME.

This bridge, built in 1888, crosses the Tiber near the historical island called Isola Tiberina, which is said to have been formed by the mass of grain plundered by the population in a revolt against the Tarquins. Tradition has it that the god Esculapius hid himself in this island in the disguise of a serpent which the priests had captured in a Greek temple and brought to Rome in order to avoid a plague. This island was afterward cut to the shape of a vessel, and there was built the temple of Esculapius, of which are still to be seen the remains.

The bridge is formed with two large iron arches of 173 feet 8 inches chord and 16 feet 4 inches pitch. The distance between the parapets is 65 feet 6 inches. Each span is composed of thirteen arched ribs, and the pavement is of stone. The central pier is 39 feet 3 inches wide at the top and 46 feet wide at the base. The abutments and the central pier have been put in place upon foundations sunk by means of compressed air caissons to a depth of 50 feet below low-water level of the river, and rest upon a layer of compact sand. The foundations of the abutments and central pier have required 29,925 cubic yards of masonry, while 2,930 cubic yards of *travertino* and 1,007 cubic yards of granite of Baveno have been used for the ornamental portions.

The weight of iron used in the construction of the two arches is 1,680 tons. A maximum load of 880 tons on the bridge gives a stress of 8,450 pounds per square inch on the ironwork. This bridge cost $720,000, of which $200,000 has been expended upon iron work. At the two ends of the bridge there are four granite columns of the ancient *miliarie* form, bearing in bronze the dates of the principal campaigns of Garibaldi: *i. e.*, Montevideo, 1847; Roma, 1848; Varese, 1859; Marsala, 1860; Volturno, 1860; Bezzecca, 1866; Mentana, 1867; Digione, 1871.

This bridge was designed by Signor Angelo Vescovali, who holds the position of chief engineer of the hydraulic service of the city of Rome—who designed the Margherita and Magliana bridges—and the works have been executed under his supervision by Messrs. Zschokke & Terrier. The iron work was supplied by Messrs. Tardy & Benech, of Savona.—*Industries.*

How Some Fires Originate.

A list of unusual and curiously caused fires has been compiled and the *Railway Review* mentions some of the number. It includes a factory fire which was traced to a railway truck, an over-heated axle having thrown a car from the track and set fire to a petroleum tank from which the flames spread to the building. An instance is given in which a bucket of greasy waste was ignited by the friction of a belt which sagged against it. In a harmless case of spontaneous ignition of oily waste, this material, with some wood chips, had been thrown into the fire box of an idle locomotive, shortly after which the workmen were surprised by the blowing off of steam by the engine. Another fire was due to oily waste in a manner which could not well be foreseen. Only heavy mineral oils were used, and a place was provided for the waste, but a cockchafer crawled from the receptacle directly to a gas jet, when the creature was quickly consumed, and the oily cotton filaments adhering to its body spread the fire. Well known incendiaries are photographic and other lenses which act as burning glasses, and bright tight plates, which serve as concave mirrors. A plumber's exploit consisted in applying the flame test to a newly made joint in a gas pipe, then covering the pipe without noticing a small blue flame, which was discovered some six weeks afterward, when the leak had become somewhat enlarged. A nail glanced from a carpenter's hammer into the conveyer of raw material in a jute factory, rubbed against the drum and produced a spark which set fire to the place. A flood burned one factory by causing a pile of iron filings to oxidize so rapidly as to become intensely heated. A stream from the firemen's hose started a second fire in New York while putting out one in a small building, a neighboring shed containing quicklime having been penetrated by the water.

To Thaw Out Frozen Pipes.

The *Builders' Gazette* recommends as an easy and cheap method of preventing pipes that are on or near the surface of the ground from freezing to cover them first with a thin layer of sawdust, spent tan bark, or any kind of litter. Next a layer of quicklime in lumps the size of a hen's egg up to the size of a large orange, and over this place another thick litter to retain the warmth. The theory of this is that the gradual slaking of the lime will develop sufficient heat to prevent freezing of the pipe. A covering of this sort, if properly protected, will prevent a pipe from freezing during an entire winter, the heat from the slaking lime being given off slowly. Pipes that have been frozen can be quickly thawed by covering them with a layer of quicklime in lumps and slaking it by pouring on water. The object of the layer of litter next to the pipe is to prevent corrosion by contact with the lime.

Pipes exposed may be prevented from bursting in freezing by a very simple device. Water, like everything else, contracts in volume, slightly, by cold to a certain point—the freezing point. Unlike everything else, water, as it freezes, suddenly expands with a force nothing can resist. Pipes and vessels of the toughest metals burst as easily as clay pipes from the freezing of water so confined in them as to permit no room for its expansion. If a short piece of rubber hose, securely tied at each end so as to prevent the air in it from escaping, is inserted inside the water pipe, about the point where it is most likely to freeze, it will prevent the bursting of the pipe. The expansion of the freezing water is counteracted by the compression of the air confined in the rubber hose and thus relieves the pressure on the pipe.