The Inventions, Researches and Writings of Nikola Tesla

With Special Reference to His Work in Polyphase

Currents and High Potential Lighting

by Thomas Commerford Martin

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Excerpted from Chapter LXIII: text pgs. 486 - 493; PDF pgs. 314 - 321

Due to the significance of "Pentagon Aliens", ch. 8, by William Lyne

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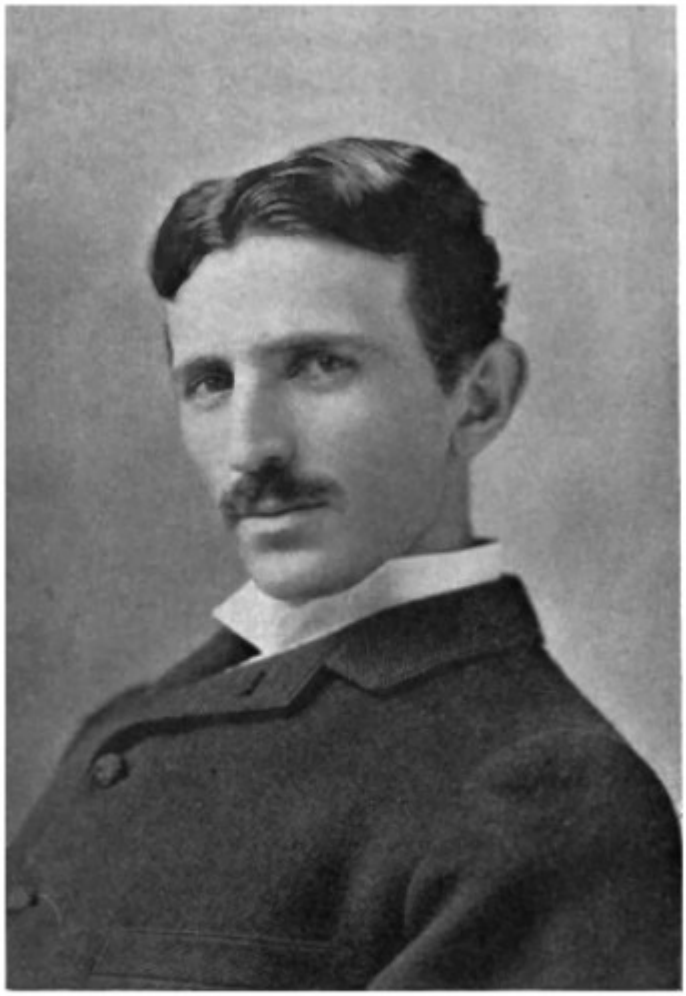


Nikola Tesla

Chapter LXIII – The Tesla Mechanical and Electrical Oscillators

Editor's note: Several times, the author uses the word 'preponderate' in reference to alternating impulses to describe the energetic preponderance of one-half phase over the other producing a direct current between them in excess of the input power. This admits overunity and free energy in defiance of conventional physics implying a failure of self-integrity among physicists and electrical engineers.

On the evening of Friday, August 25, 1893, Mr. Tesla delivered a lecture on his mechanical and electrical oscillators, before the members of the Electrical Congress, in the hall adjoining the Argicultural Building, at the World's Fair, Chicago. Besides the apparatus in the room, he employed an air compressor, which was driven by an electric motor.

Mr. Tesla was introduced by Dr. Elisha Gray, and began by stating that the problem he had set out to solve was to construct, first, a mechanism which would produce oscillations of a perfectly constant period independent of the pressure of steam or air supplied, within the widest limits, and also independent of frictional losses and load. Secondly, to produce electric currents of a perfectly constant period independently of the working conditions, and to produce these currents with mechanism which should be reliable and positive in its action without resorting to spark gaps and breaks. This he successfully accomplished in his apparatus, and with this apparatus, now, scientific men will be provided with the necessaries for carrying on investigations with alternating currents with great precision. These two inventions Mr. Tesla called, quite appropriately, a mechanical and an electrical oscillator, respectively.

The former is substantially constructed in the following way. There is a piston in a cylinder made to reciprocate automatically by proper dispositions of parts, similar to a reciprocating tool. Mr. Tesla pointed out that he had done a great deal of work in perfecting his apparatus so that it would work efficiently at such high frequency of reciprocation as he contemplated, but he did not dwell on the many difficulties encountered. He exhibited, however, the pieces of a steel arbor which had been actually torn apart while vibrating against a minute air cushion.

With the piston above referred to there is associated in one of his models in an independent chamber an air spring, or dash pot, or else he obtains the spring within the chambers of the oscillator itself. To appreciate the beauty of this it is only necessary to say that in that disposition, as he showed it, no matter what the rigidity of the spring and no matter what the weight of the moving parts, in other words, no matter what the period of vibrations, the vibrations of the spring are always isochronous with the applied pressure. Owing to this, the results obtained with these vibrations are truly wonderful. Mr. Tesla provides for an air spring of tremendous rigidity, and he is enabled to vibrate big weights at an enormous rate, considering the inertia, owing to the recoil of the spring. Thus, for instance, in one of these experiments, he vibrates a weight of approximately 20 pounds at the rate of about 80 per second and with a stroke of about 7/8 inch, but by shortening the stroke the weight could be vibrated many hundred times, and has been, in other experiments.

To start the vibrations, a powerful blow is struck, but the adjustment can be so made that only a minute effort is required to start, and, even without any special provision it will start by merely turning on the pressure suddenly. The vibration being, of course, isochronous, any change of pressure merely produces a shortening or lengthening of the stroke. Mr. Tesla showed a number of very clear drawings, illustrating the construction of the apparatus from which its working was plainly discernible. Special provisions are made so as to equalize the pressure within the dash pot and the outer atmosphere. For this purpose the inside chambers of the dash pot are arranged to communicate with the outer atmosphere so that no matter how the temperature *[emphasis is mine – editor's* note] of the enclosed air

might vary, it still retains the same mean density as the outer atmosphere, and by this means a spring of constant rigidity is maintained. *[editor's note – This tells me that the temperature and density is slightly above that of the liquefaction of air undergoing compression while the air exiting the system has achieved the liquid state once this device chills down to its optimal level of efficiency after a short duration after its initial startup. By recycling the liquid exhaust, and combining this with fresh air, the intake will flash boil the liquid air and offer an instant explosive force of compression ready to drive the piston. The expansive phase of the air spring will decompress the air and drop its temperature back down to its liquefaction immediately prior to its exit. This super-cold liquid exhaust cannot be used to cool the coils,* ***M M****, to raise their limit of magnetic saturability rather than bolt them to a much larger mass of iron without losing their liquid state outside this device and prior to their re-entry. William Lyne quotes Tesla: "For every two hundred pounds of iron attached to this device, one horsepower is added to its output." This one sentence of Thomas Martin clarifies for me the relevance of the method for liquifying air patented by Carl Linde, and others, around the same time as Tesla's laboratory fire of 1895 which destroyed all of his evidence for patenting this, and other inventions, revolving around liquefaction. This one text by Thomas Martin, published two years prior to Tesla's lab fire, probably sealed his fate.]* Now, of course, the pressure of the atmosphere may vary, and this would vary the rigidity of the spring, and consequently the period of vibration, and this feature constitutes one of the great beauties of the apparatus; for, as Mr. Tesla pointed out, this mechanical system acts exactly like a spring tightly stretched between two points, and with fixed nodes, so that slight changes of the tension do not in the least alter the period of oscillation. *[One-sixteenth of an inch piston stroke length, on page five of this text, suggests a nearly equivalent temperature and pressure for the air lying outside either end of the piston sufficient to readily maintain a state very near to that of its liquefaction, at all times, despite the rigors of compression and decompression – editor's note.]*

The applications of such an apparatus are, of course, numerous and obvious. The first is, of course, to produce electric currents, and by a number of models and apparatus on the lecture platform, Mr. Tesla showed how this could be carried out in practice by combining an electric generator with his oscillator. He pointed out what conditions must be observed in order that the period of vibration of the electrical system might not disturb the mechanical oscillation in such a way as to alter the periodicity, but merely to shorten the stroke. He combines a condenser with a self-induction*[by placing an inductor on its own sub-branched circuit in parallel with the condenser creating a self-resonant LC tank circuit – editor's note]*, and gives to the electrical system the same as that at which the machine itself oscillates, so that both together then fall in step and electrical and mechanical resonance is obtained, and maintained absolutely unvaried.

Next he showed a model of a motor with delicate wheelwork, which was driven by these currents at a constant speed, no matter what the air pressure applied was, so that this motor could be employed as a clock. He also showed a clock so constructed that it could be attached to one of the oscillators, and would keep absolutely correct time. Another curious and interesting feature which Mr. Tesla pointed out was that, instead of controlling the motion of the reciprocating piston by means of a spring, so as to obtain isochronous vibration, he was actually able to control the mechanical motion by the natural vibration of the electro-magnetic system, and he said that the case was a very simple one, and was quite analogous to that of a pendulum. Thus, supposing we had a pendulum of great weight, preferably, which would be maintained in vibration by force, periodically applied; now that force, no matter how it might vary, although it would oscillate the pendulum, would have no control over its period.

Mr. Tesla also described a very interesting phenomenon which he illustrated by an experiment. By means of this new apparatus, he is able to produce an alternating current in which the E. M. F. of the impulses in one direction preponderates over that of those in the other, so that there is produced the effect of a direct current. In fact he expressed the hope that these currents would be capable of

application in many instances, serving as direct currents. The principle involved in this preponderating E. M. F. he explains in this way: Suppose a conductor is moved into the magnetic field and then suddenly withdrawn. If the current is not retarded, then the work performed will be a mere fractional one; but if the current is retarded, then the magnetic field acts as a spring. Imagine that the motion of the conductor is arrested by the current generated, and that at the instant when it stops to move into the field, there is still the maximum current flowing in the conductor; then this current will, according to Lenz's law, drive the conductor out of the field again, and if the conductor has no resistance, then it would leave the field with the velocity it entered it. Now it is clear that if, instead of simply depending on the current to drive the conductor out of the field, the mechanically applied force is so timed that it helps the conductor to get out of the field, then it might leave the field with higher velocity then it entered it, and thus one impulse is made to preponderate in E. M. F. over the other.

With a current of this nature, Mr. Tesla energized magnets strongly, and performed many interesting experiments bearing out the fact that one of the current impulses preponderates. Among them was one in which he attached to his oscillator a ring magnet with a small air gap between the poles. This magnet was oscillated up and down 80 times a second. A copper disc, when inserted within the air gap of the ring magnet, was brought into rapid rotation. Mr. Tesla remarked that this experiment also seemed to demonstrate that the lines of flow of current through a metallic mass are disturbed by the presence of a magnet in a manner quite independent of the so-called Hall effect.*[...implying the birth of a Homopolar generator: a modification of the Hall effect – editor's note.]* He showed also a very interesting method of making a connection with the oscillating magnet. This was accomplished by attaching to the magnet small insulated steel rods, and at these points the terminals of a direct current source were attached. Mr. Tesla also pointed out that one of the uses of currents, such as those produce in his apparatus, would be to select any given one of a number of devices connected to the same circuit by picking out the vibration by resonance. There is indeed little doubt that with Mr. Tesla's devices, harmonic and synchronous telegraphy will receive a fresh impetus, and vast possibilities are again opened up.

Mr. Tesla was very much elated over his latest achievements, and said that he hoped that in the hands of practical, as well as scientific, men the devices described by him would yield important results. He laid special stress on the facility now afforded for investigating the effect of mechanical vibration in all directions, and also showed that he had observed a number of facts in connection with iron cores.

The engraving, Fig. 312, shows, in perspective, one of the forms of apparatus used by Mr. Tesla in his earlier investigations in this field of work, and its interior construction is made plain by the sectional view shown in Fig. 313. *[Both figures are placed at the end of this text for better formatting.]*

It will be noted that the piston **P** is fitted into the hollow of a cylinder **C** which is provided with channel ports **O O**, and **T**, extending all around the inside surface. In this particular apparatus there are two channels **O O** for the outlet of the working fluid and one, **I**, for the inlet. The piston **P** is provided with two slots **S S'** at a carefully determined distance, one from the other. *[The width of the groove for slot **S'** appears to be one thirty-second of an inch, 1/32", if the distance the piston travels is taken to be twice that - editor's note.]* The tubes **T T** which are screwed into the holes drilled into the piston, establish communication between the slots **S S'** and chambers on each side of the piston, each of these chambers connecting with the slot which is remote from it. The piston **P** is screwed tightly on a shaft **A** which passes through fitting boxes at the end of the cylinder **C**. The boxes project to a carefully determined distance into the hollow of the cylinder **C**, thus determining the length of the stroke.

Surrounding the whole is a jacket **J**. This jacket acts chiefly to diminish the sound produced by the oscillator and as a jacket when the oscillator is driven by steam, in which case a somewhat different arrangement of the magnets is employed. The apparatus here illustrated was intended for demonstration purposes, air being used as most convenient for this purpose.

A magnetic frame **M M** is fastened so as to closely surround the oscillator and is provided with energizing coils which establish two strong magnetic fields on opposite sides. The magnetic frame is made up of thin sheet iron. In the intensely concentrated field thus produced, there are arranged two pairs of coils **H H** supported in metallic frames *[could these metallic frames be made of aluminum? - editor's note]* which are screwed on the shaft **A** of the piston and have additional bearings in the boxes **B B** on each side. The whole is mounted on a metallic base resting on two wooden blocks.

The operation of the device is as follows: The working fluid being admitted through an inlet pipe to the slot **I** and the piston being supposed to be in the position indicated, it is sufficient, though not necessary, to give a gentle tap on one of the shaft ends protruding from the boxes **B**. Assume that the motion imparted be such as to move the piston to the left (when looking at the diagram) then the air rushes through the slot **S'** and the tube **T** into the chamber to the left. The pressure now drives the piston towards the right and, owing to its inertia, it overshoots the position of equilibrium and allows the air to rush through the slot **S** and tube **T** into the chamber to the right, while the communication to the left hand chamber is cut off, the air of the latter chamber escaping through the outlet **O** on the left. On the return stroke a similar operation takes place on the right hand side. This oscillation is maintained continuously and the apparatus performs vibrations from a scarcely perceptible quiver amounting to no more than 1/16 of an inch*[the original text had a blank denominator while the second edition was visibly corrected to read ¼ of an inch, using a vertically offset typeset, but William Lyne claims 1/16 of an inch – editor's note]*, up to vibrations of a little over 3/8 of an inch, according to the air pressure and load. It is indeed interesting to see how an incandescent lamp is kept burning with the apparatus showing a scarcely perceptible quiver.

To perfect the mechanical part of the apparatus so that oscillations are maintained economically was one thing, and Mr. Tesla hinted in his lecture at the great difficulties he had first encountered to accomplish this. But to produce oscillations which would be of constant period was another task of no mean proportions. As already pointed out, Mr. Tesla obtains the constancy of period in three distinct ways. Thus, he provides properly calculated chambers, as in the case illustrated, in the oscillator itself; or he associates with the oscillator as air spring of constant resilience. But the most interesting of all, perhaps, is the maintenance of the constancy of oscillation by the reaction of the electromagnetic part of the combination. Mr. Tesla winds his coils, by preference, for high tension and associates with them a condenser, making the natural period of the combination fairly approximating to the average period at which the piston would oscillate without any particular provision being made for the constancy of period under varying pressure and load. As the piston with the coils is perfectly free to move, it is extremely susceptible to the influence of the natural vibration set up in the circuits of the coils **H H**. The mechanical efficiency of the apparatus is very high owing to the fact that friction is reduced to a minimum and the weights which are moved are small; the output of the oscillator is therefore a very large one.

Theoretically considered, when the various advantages which Mr. Tesla holds out are examined, it is surprising, considering the simplicity of the arrangement, that nothing was done in this direction before. No doubt many inventors, at one time or another, have entertained the idea of generating currents by attaching a coil or a magnetic core to the piston of a steam engine, or generating currents by the vibrations of a tuning fork, or similar devices, but the disadvantages of such arrangements from an engineering standpoint are obvious. Mr. Tesla, however, in the introductory remarks of his lecture, pointed how by a series of conclusions he was driven to take up this new line of work by the necessity of producing currents of constant period and as a result of his endeavors to maintain electrical oscillation in the most simple and economical manner possible.

[editor's note – I've fashioned an animated GIF and two videos illustrating the action of the piston and its resulting air flow.]

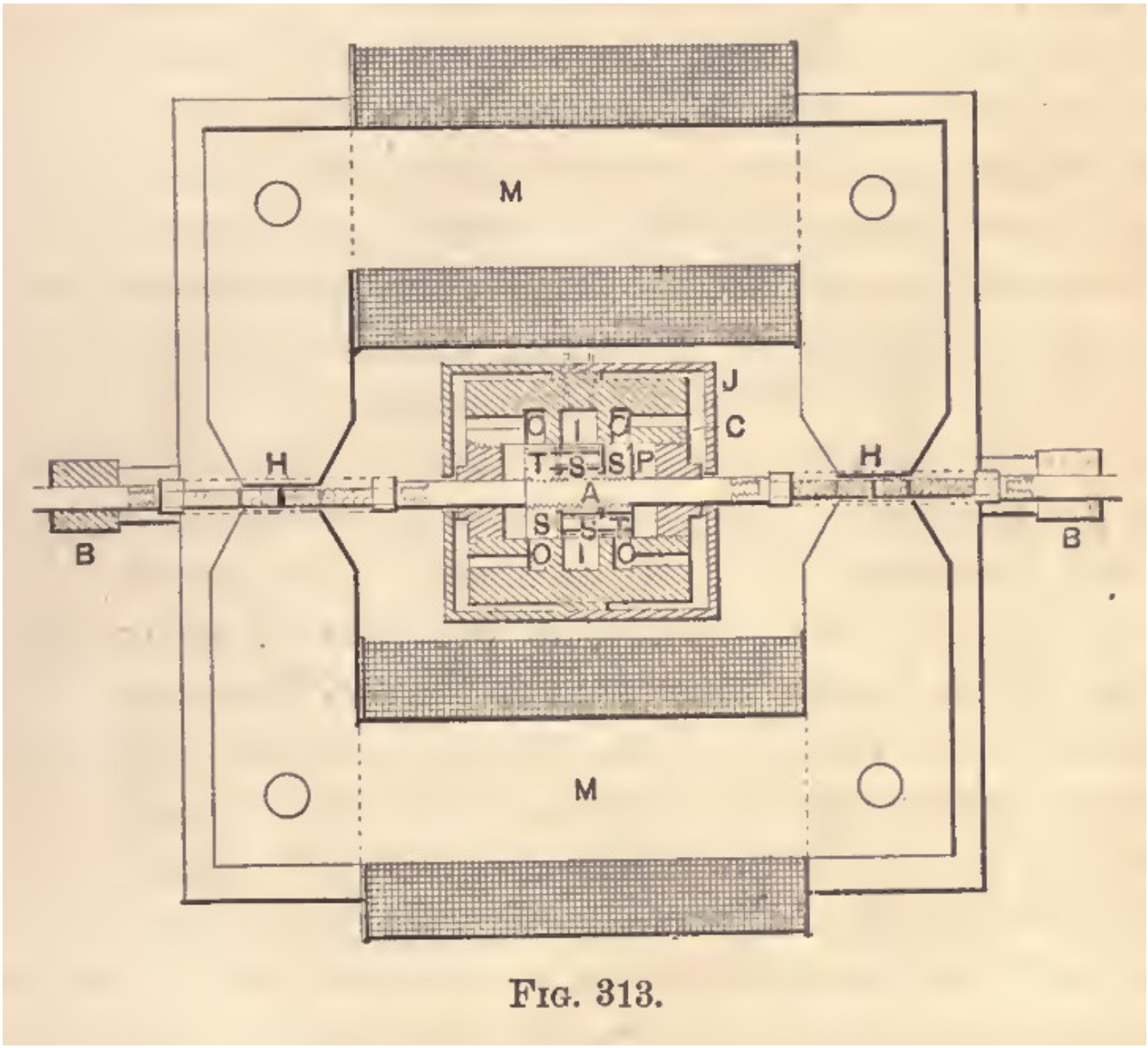
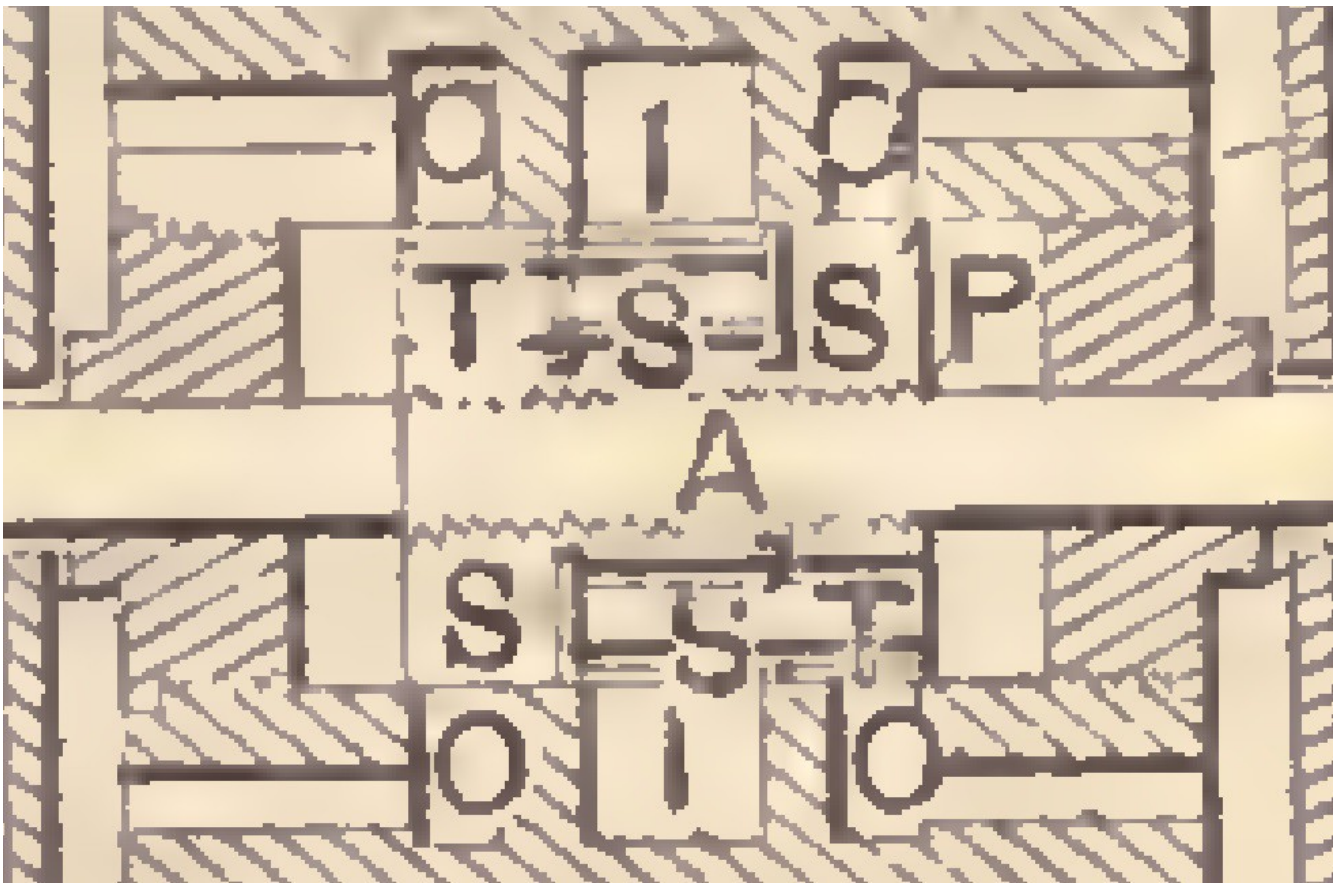


FIG. 313.

Fig. 312



Blow Up of Fig. 313