No. 793,777. PATENTED JULY 4 1905.

R. A. FESSENDEN.

CONDENSER.

APPLICATION FILED MAR. 30, 1905.

5 SHEETS—SHEET 1.

Fig. 1.

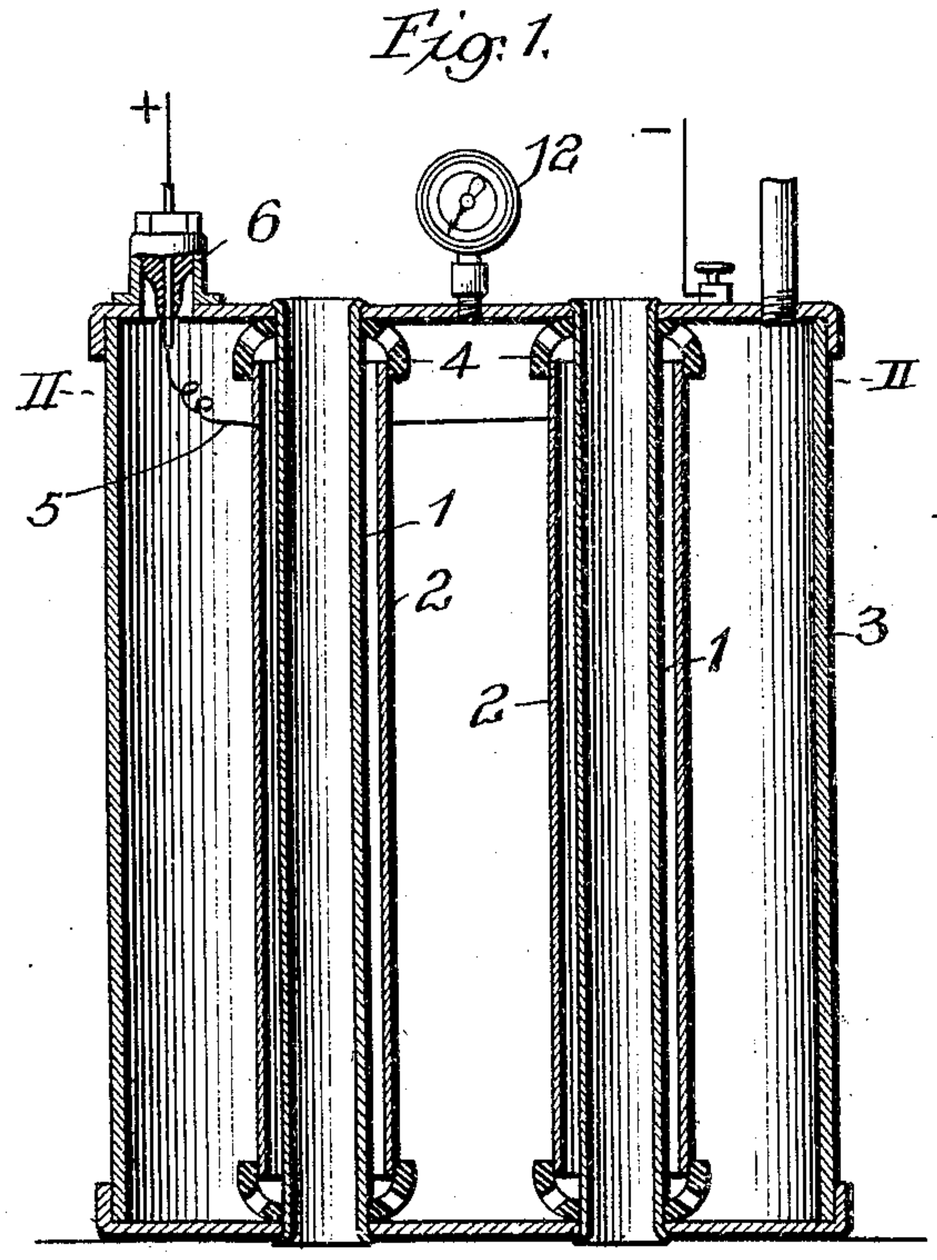


Fig. 3.

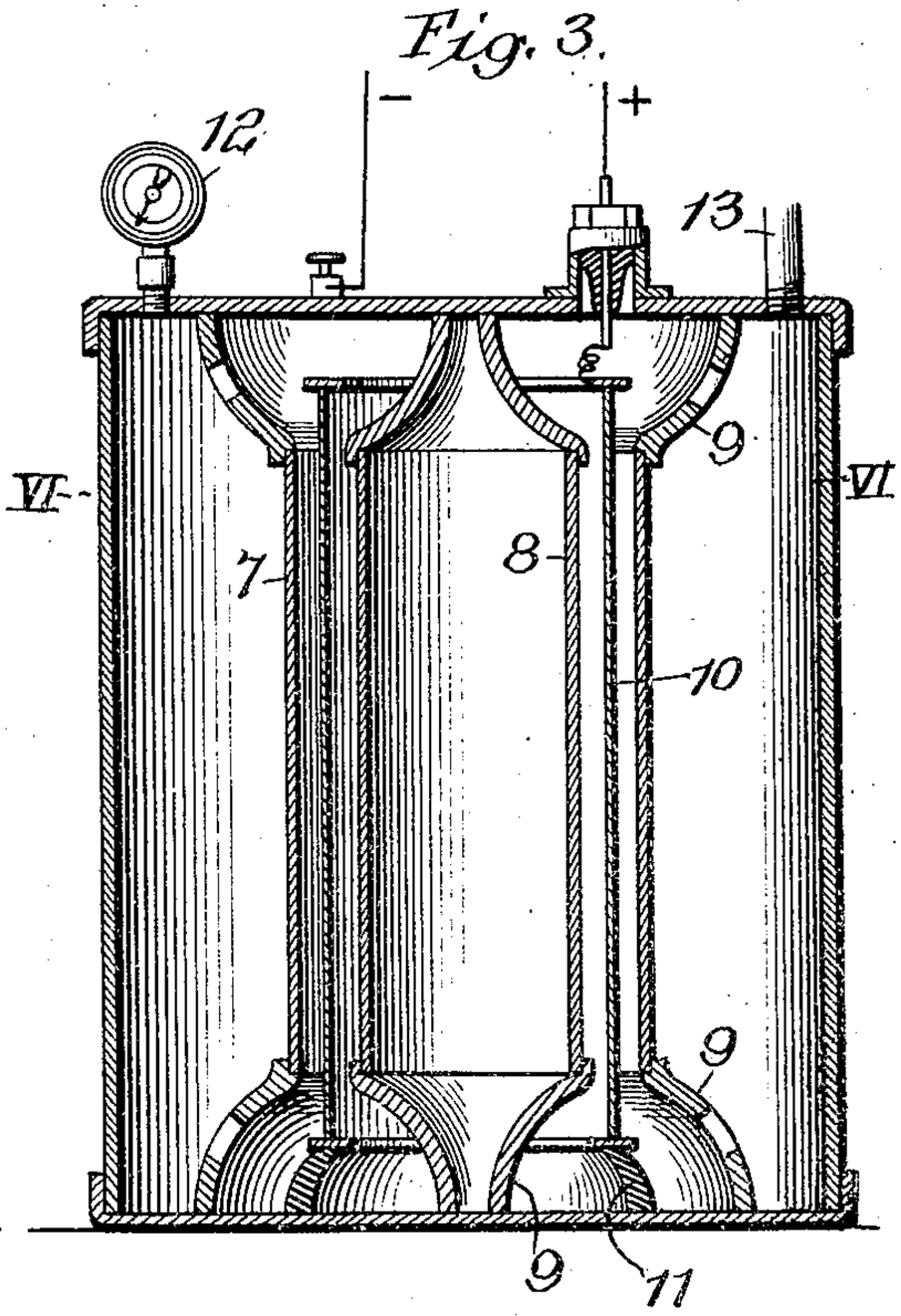


Fig. 2.

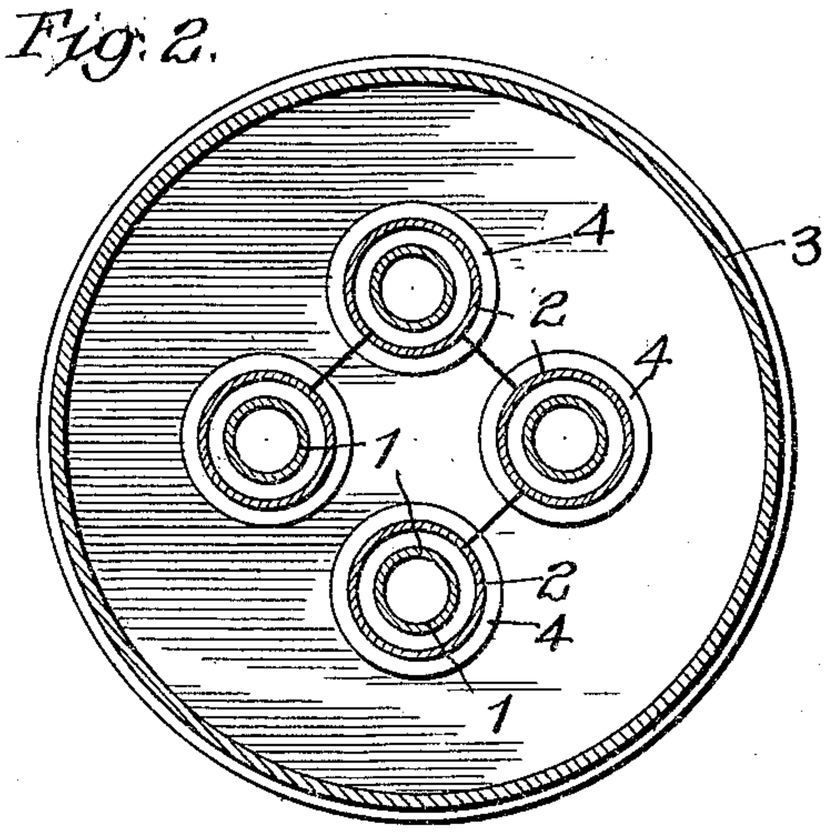
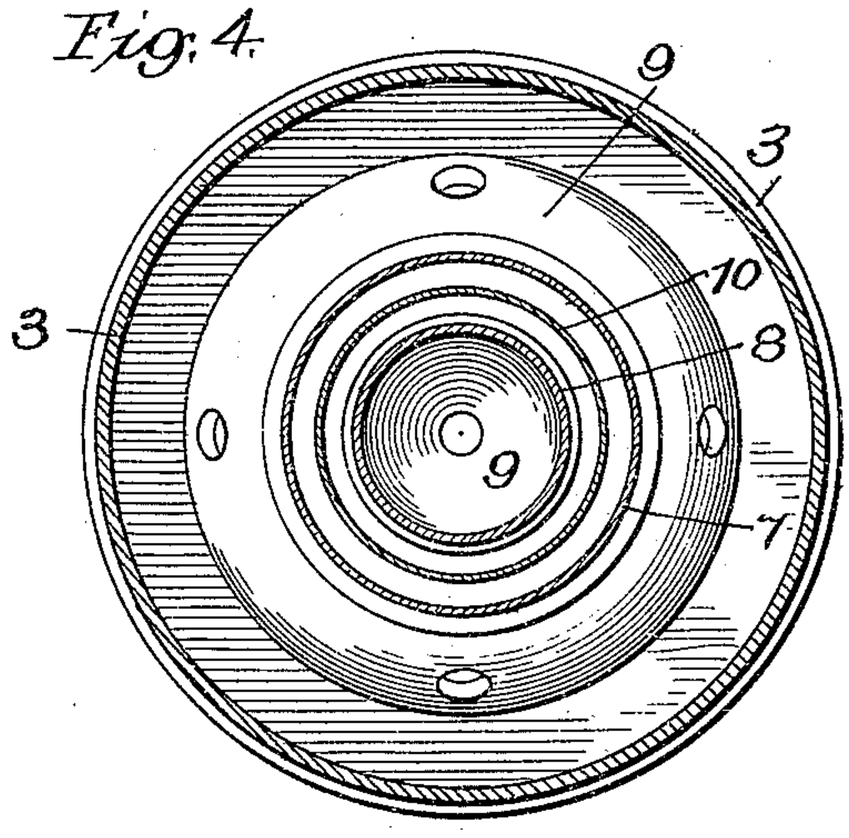


Fig. 4.



Witnesses:

Fred Kirchner

Herbert Bradley.

Inventor.

Reginald A. Fessenden

by Dennis & Wolcott

Attorney.

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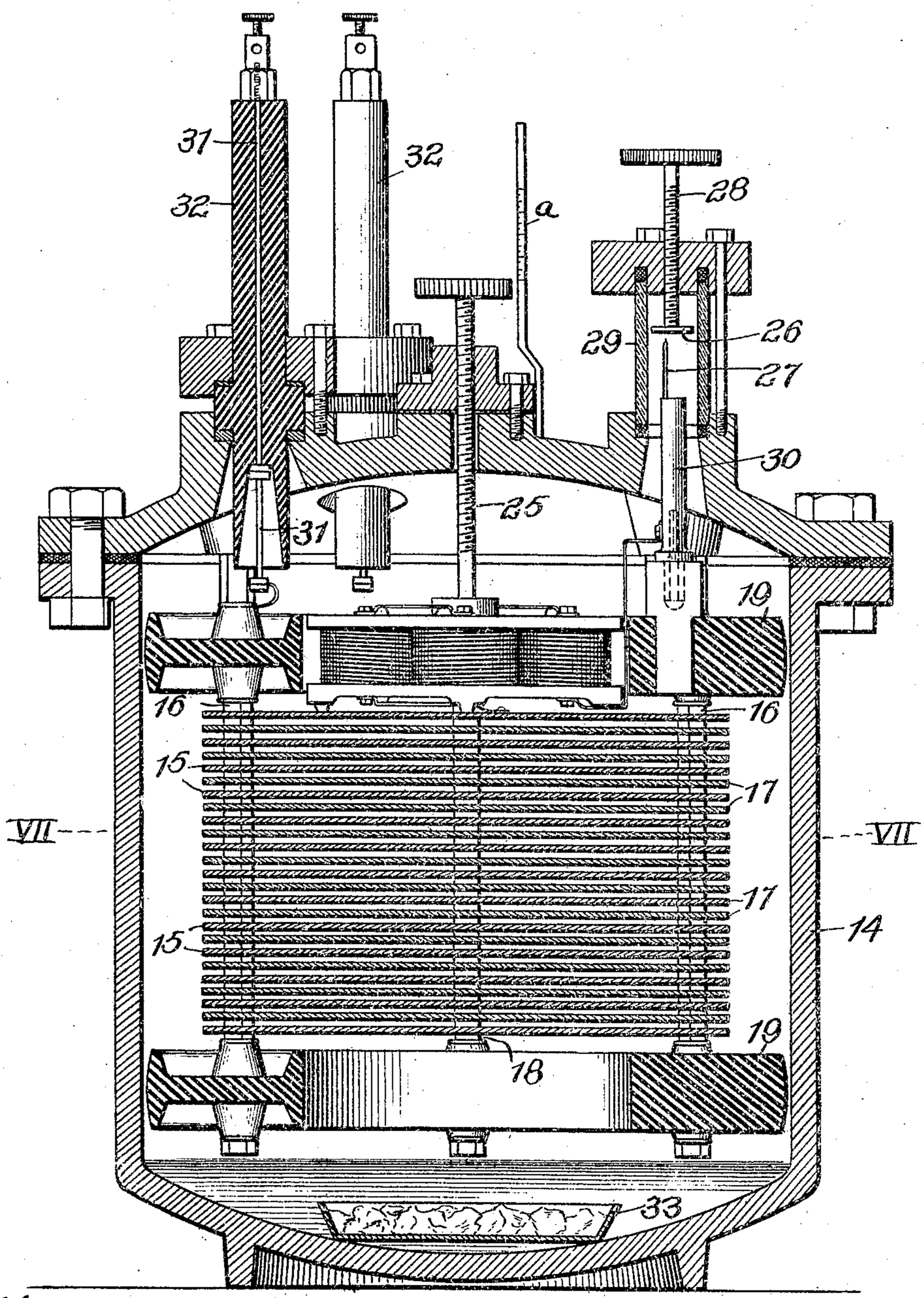
5 SHEETS—SHEET 2.

Fig. 5.



Witnesses:

Fred Steinmer

Herbert Bradley

Inventor:

Reginald A. Fessenden

by Dennis & Colett

Attorney.

No. 793,777. PATENTED JULY 4, 1905.

R. A. FESSENDEN.

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5 SHEETS—SHEET 3.

Fig. 6.

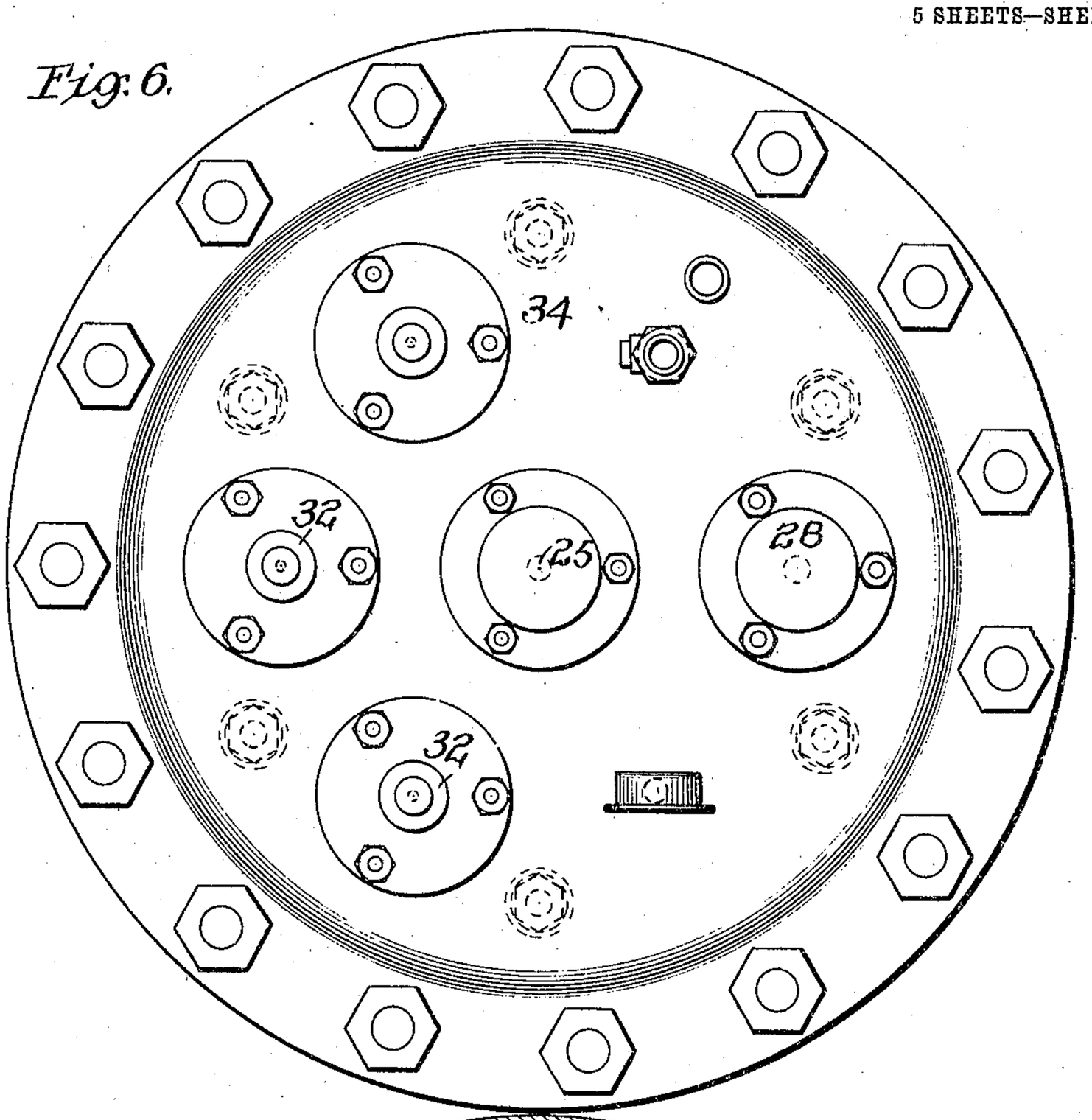
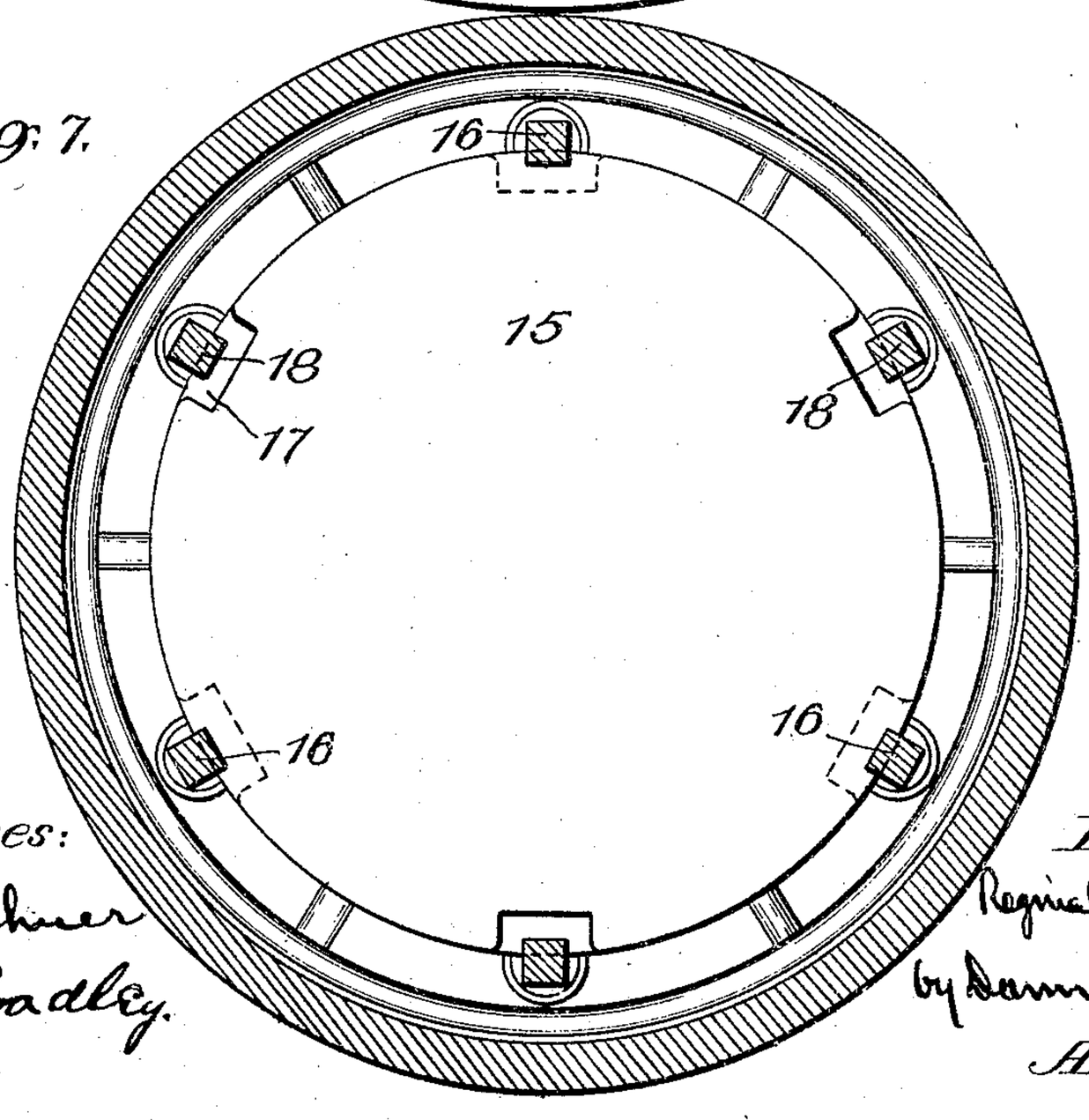


Fig. 7.



Witnesses:
Fred Kirchner
Herbert Bradley.

Inventor:
Reginald A. Fessenden
by Dennis S. Wolcott
Attorney

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5 SHEETS—SHEET 4.

Fig. 8.

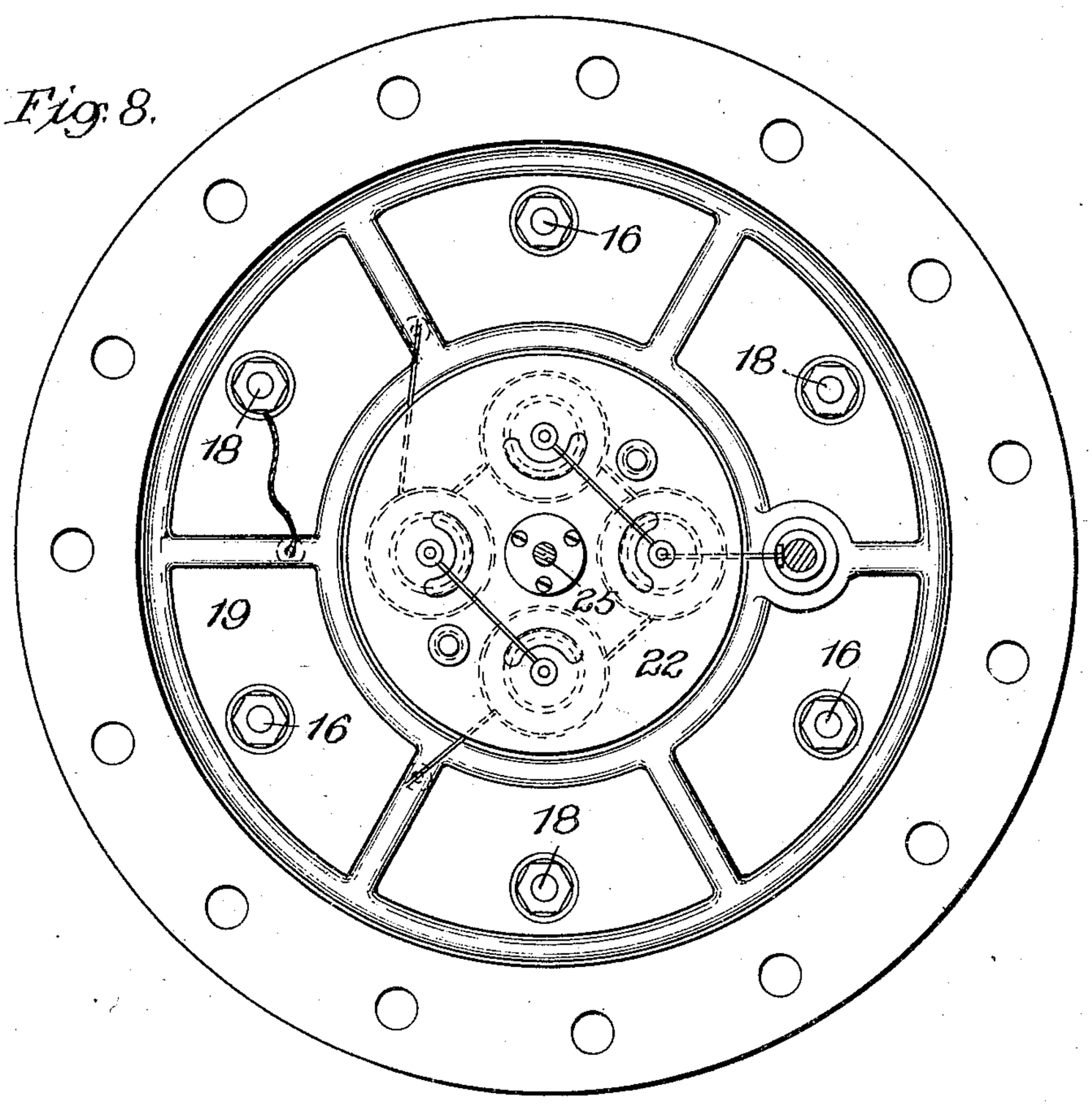
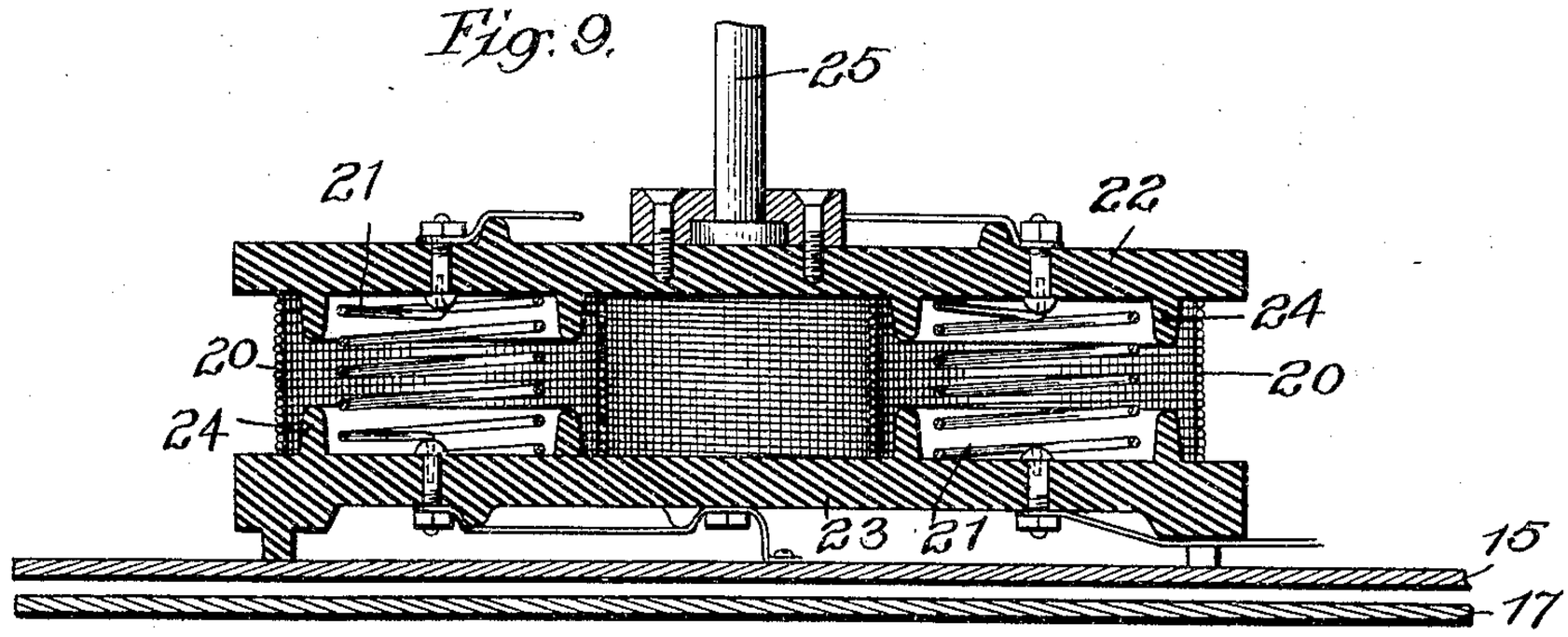


Fig. 9.



Witnesses:

Fred Kirchner.

Herbert Bradley.

Inventor.

Reginald A. Fessenden

by Dennis & Wolcott

Attorney

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APPLICATION FILED MAR. 30, 1905.

5 SHEETS—SHEET 5.

Fig. 10.

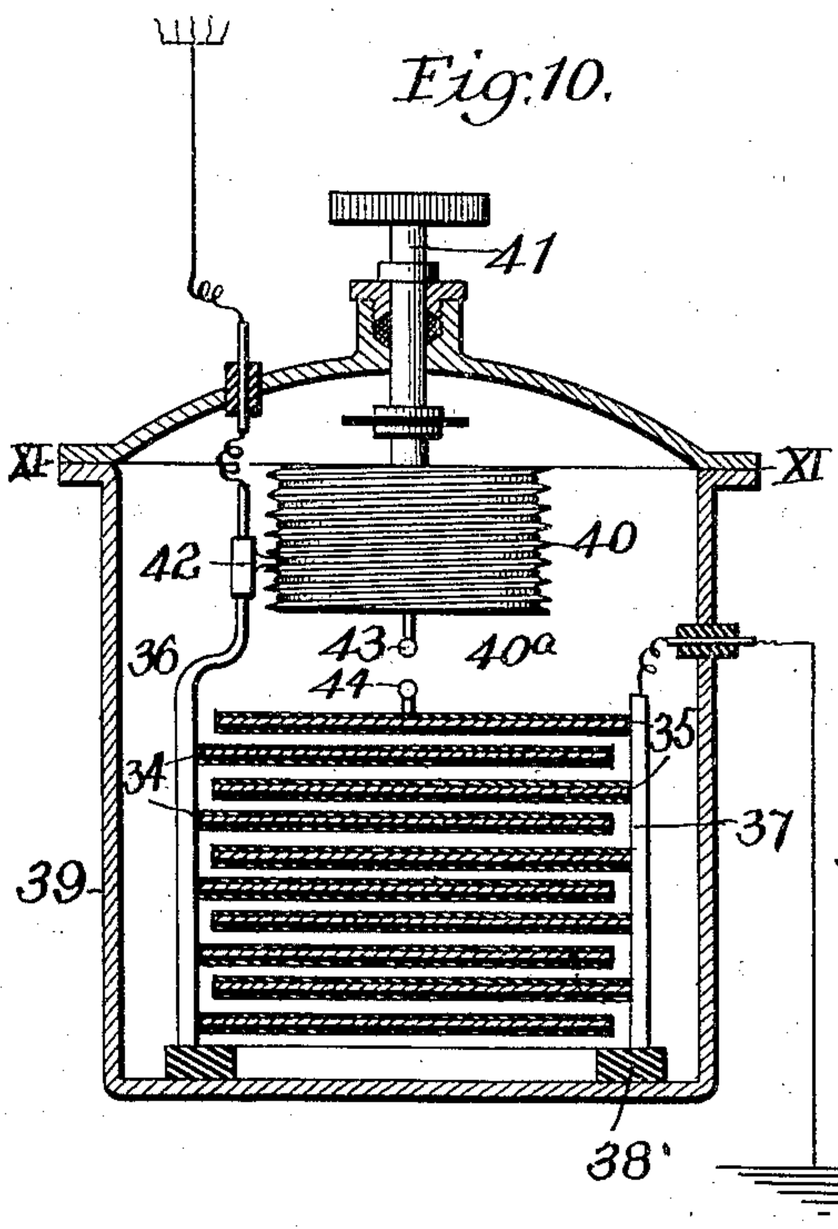


Fig. 12.

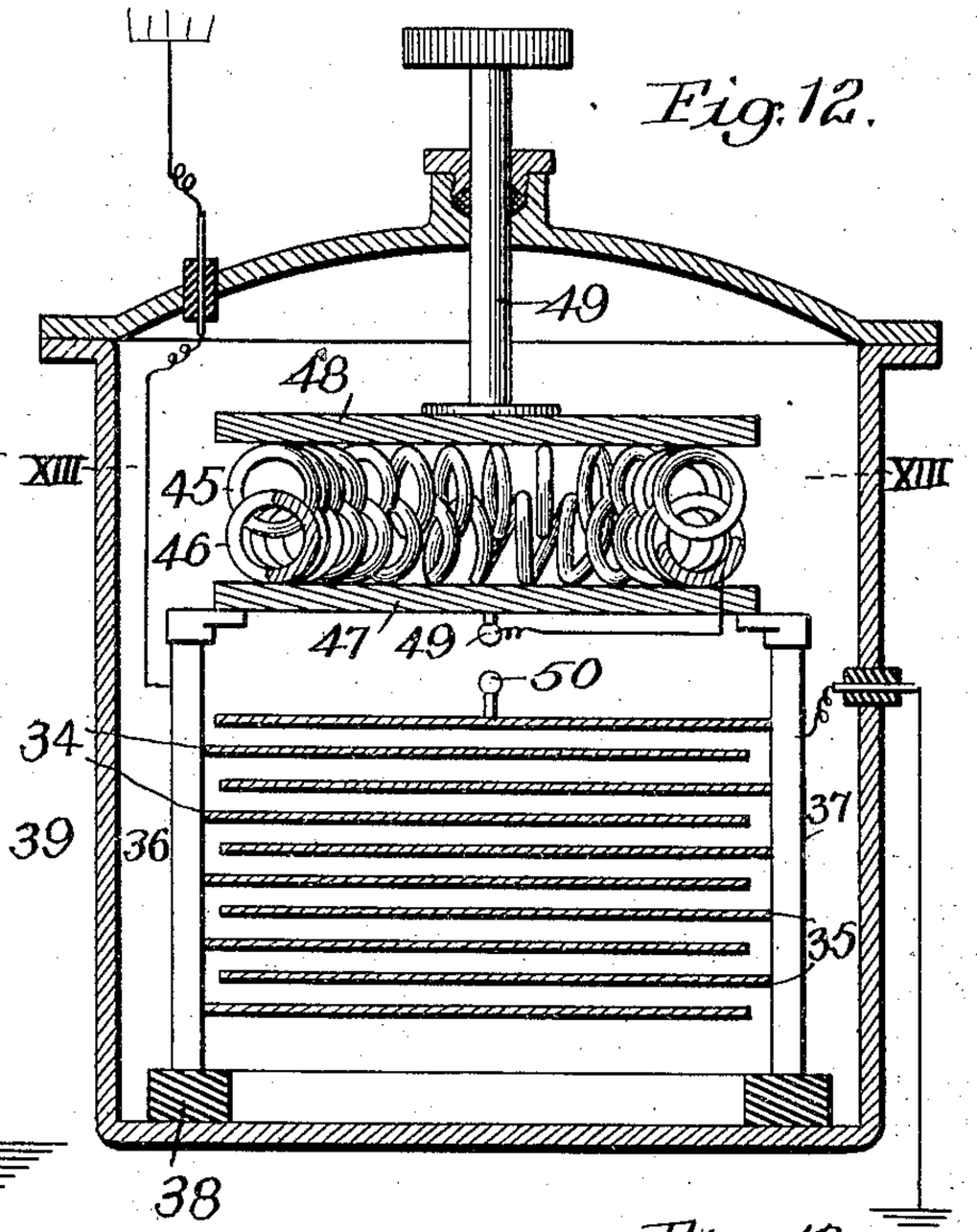


Fig. 11.

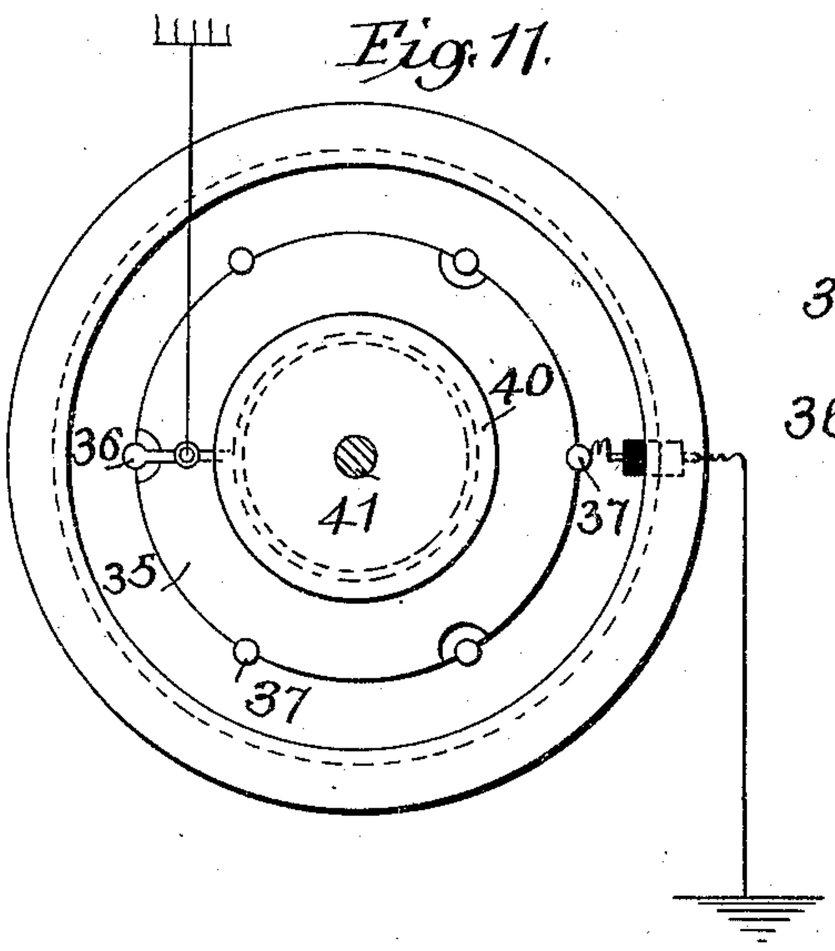
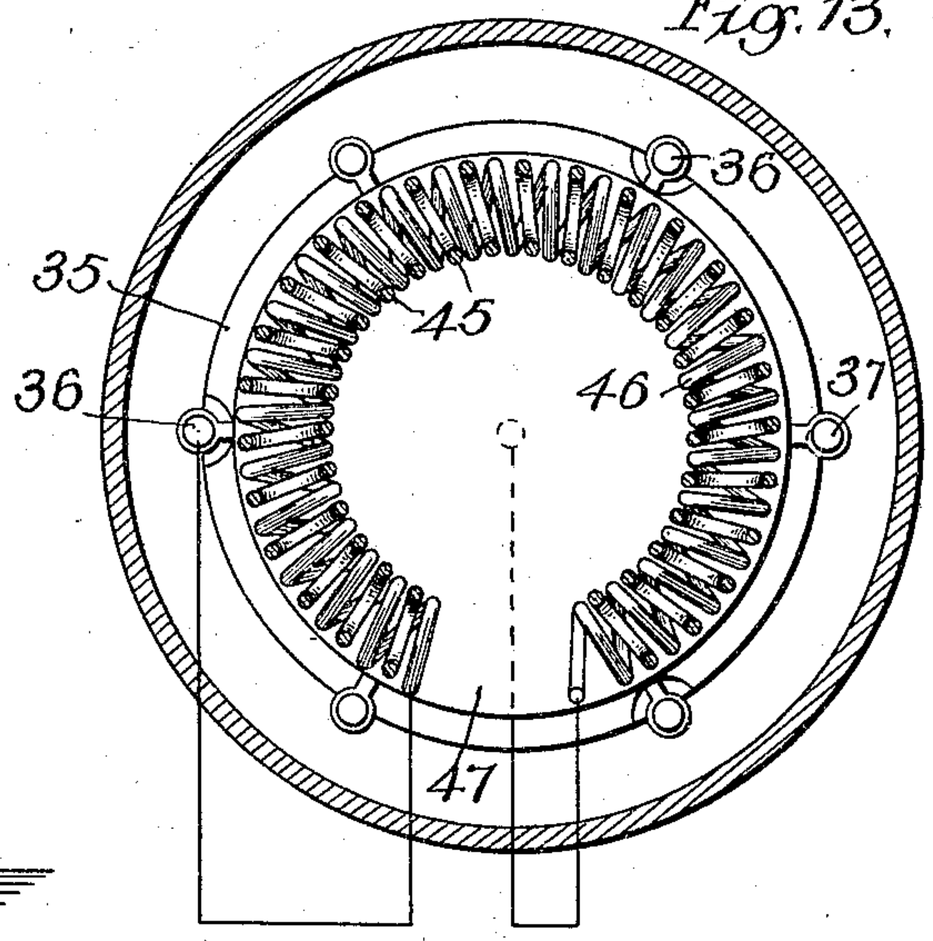


Fig. 13.



Witnesses:
Fred Kirchner
Herbert Bradley.

Inventor.
Reginald A. Fessenden
by Dennis & Wolcott
Attorney.

No. 793,777. Patented July 4, 1905.

UNITED STATES PATENT OFFICE.

REGINALD A. FESSENDEN, OF WASHINGTON, DISTRICT OF COLUMBIA.

CONDENSER.

SPECIFICATION forming part of Letters Patent No. 793,777, dated July 4, 1905.

Application filed March 30, 1905. Serial No. 252,944.

To all whom it may concern:

Be it known that I, REGINALD A. FESSENDEN, a citizen of the United States, residing at Washington, District of Columbia, have invented or discovered certain new and useful Improvements in Condensers, of which improvements the following is a specification.

The invention described herein relates to certain improvements in condensers whereby a high efficiency in all electrical work where condensers are employed is obtained, but especially in the generation and transmission of electromagnetic waves.

One of the most serious difficulties encountered in connection with the generation of electric oscillation has been the impracticability of obtaining a condenser having a dielectric suitable or sufficient as regards its strength and other characteristics. The condensers heretofore known and used are deficient for the generation, transmission, and reception of electrical oscillations in the following particulars:

(*a*) The dielectric may change its specific inductive capacity with the potential and thereby distort the wave form, as was discovered many years ago by me, as regards water and certain liquids.

(*a*) I have ascertained that when water and certain other liquids are used as dielectrics a change of potential will produce a change in the specific inductive capacity of the dielectric, causing a distortion of the wave form and thereby rendering a sharp tuning impossible. To some extent distortion of the wave form for the same reason occurs when glass is used as a dielectric.

(*b*) The dielectric may change its capacity with the frequency and with the temperature. These defects, which are common to nearly all dielectrics cause considerable loss and prevent the maintenance of accurate tuning.

(*c*) Losses of energy and heating of the dielectrics and a consequent lowering of resonance may occur through dielectric hysteresis and through electrical conductivity of the dielectric.

(*d*) The dielectric may give brush discharges when subjected to high potential, causing serious loss. I have ascertained by actual measurement that the possible loss from this source with glass-plate condensers may be equal to fifty per cent. (50%) of the energy. Air under ordinary pressures is also subject to similar loss.

(*e*) The condenser may be weak dielectrically, rendering necessary a large increase in the bulk of the condenser with consequent increase in cost, as in condensers using oil or air under ordinary pressures as a dielectric.

(*f*) The dielectric may not endure under extremes of temperature, as for example, a paraffin will soften and break down at ordinary summer temperature, while a mixture of rosin and beeswax will crack and break down at a low temperature.

(*g*) It is difficult to attach the condenser-coatings to the dielectric without including air or other substances. As I have heretofore shown the imperfect contact between the coating and the dielectric causes heating with consequent loss and ultimate destruction of the condenser.

(*h*) The presence of foreign matters effects the resistance or dielectric strength of the dielectrics, as in the case of oil-condensers.

(*i*) Where it is necessary by the reason of the weakness of the dielectric to increase its size to obtain the desired capacity, the terminals required by the increase in bulk, have so much self-induction as to greatly reduce the efficiency of such condenser, which is also objectionable by reason of its size.

By reason of these and other defects, uniformly reliable results cannot be obtained in the generation, transmission and reception of energy by electromagnetic waves, as even comparatively small losses greatly affect resonance. I have found that although two condensers may appear equally efficient, one will give practically twice as much resonance as the other.

The invention described herein has for its object the provision of a condenser having a dielectric which being practically free from defects, present in condensers heretofore known and used, may properly be termed a perfect "dielectric."

The invention also has for its object the combination of such a condenser with elements or mechanism employed in the generation, transmission and reception of energy by electromagnetic waves. The invention is hereinafter more fully described and claimed.

In the accompanying drawings forming a part of this specification Figure 1 is a sectional elevation of my improved condenser. Fig. 2 is a sectional plan view, the plane of section being indicated by the line II II; Figs. 3 and 4 are similar views illustrating a modification; Fig. 5 is a sectional elevation, a combination of a form of my improved condenser with a transformer or inductance and a spark-gap; Fig. 6 is a top plan view of the same; Fig. 7 is a sectional plan on a plane indicated by the line VII VII; Fig. 8 is a top plan view of the construction shown in Fig. 5, the cover and parts carried thereby being removed; Fig. 9 is an enlarged sectional view of the transformer or inductance; Fig. 10 is a sectional elevation showing a condenser inductance and spark-gap terminals and means for adjusting the inductance; Fig. 11 is a sectional plan view on a plane indicated by the line XI XI Fig. 10; Fig. 12 is a sectional elevation of a combined condenser adjustable inductance and spark-gap terminals and Fig. 13 is a sectional plan view on a plane indicated by the line XIII XIII Fig. 12.

The facts that compression improves the insulating character of gases and that gases are self-restoring as regards their insulating qualities, do not imply that compressed gases are suitable as a dielectric for condensers, as will be readily perceived when it is considered that oil, which has high insulation and is self-restoring, is objectionable for many reasons, some of which have been stated. I have found that a great factor in the efficiency of compressed-air condensers is that above a certain pressure, apparently varying with the structure (but is generally above sixty pounds per square inch), the static discharge and its accompanying loss of energy, which may amount to fifty per cent. (50%) in air at ordinary pressures, seems to disappear entirely.

A careful examination of a condenser having an air dielectric under a pressure from one hundred and fifty to two hunderd pounds with plates one-twelfth ($\frac{1}{12}$) of an inch apart, failed to disclose any visible brush discharge up to the moment of the breaking down. On the potential being gradually raised from twenty thousand to twenty-seven thousand five hundred very many times, no brush discharge was visible at any time and there was not any apparent loss of energy at twenty-eight thousand volts, while at twenty-eight thousand five hundred volts, the spark passed in each case. By taking advantage of the discoveries I have made in this regard, it is practicable to make condensers of reasonable size and cost and having a higher efficiency than condensers with any other dielectric. I have found that my improved condenser, when applied to wireless telegraphy, is much more efficient than any other condenser, especially when used in connection with a spark-gap, also under pressure as described, and claimed in Letters Patent No. 706,741 granted to me August 12, 1902.

A simple form of my improved condenser is shown in Figs. 1 and 2. The two series of metallic or conducting members are formed by the tubes 1 and 2, the tubes of one series being arranged inside of the tubes of the other series. The pairs of tubes are properly spaced within a tank or shell 3, which may be formed of any desired material, but preferably of metal. When the tank is formed of metal the inner tubes are secured, preferably by upsetting, in holes in the ends of the tank, so as to be electrically connected therewith. The exterior tubes are held in position by annular stools 4 of insulating material, which in turn are held in position by the inner tubes or members. Passages are formed, preferably through the stools, to permit the entrance of compressed gas, and under this term is included air or any other suitable gas, between the tubes. When the tank or one or both of its ends are formed of metal, and one series of members are secured thereto in the manner described, such tank or end thereof serves to electrically connect the members of such series. The members of the other series as the tubes 2 are connected by wires as shown, and a wire or wires 5 connected to one or more of the members is passed through a plug 6 of insulating material secured to the tank or shell.

In the construction shown in Figs. 3 and 4 the concentric tubes 7 and 8 form one member of the condenser and are held in position by stools 9, preferably of conducting material, whereby such tubes are electrically connected to the containing tank or shell. The other member of the condenser is formed by a tube 10 arranged intermediate of and concentric with the tubes 7 and 8. This tube is supported and held in position by stools 11 of insulating material. The tube 10 is connected with a binding-screw by a wire passing through the plug 6 of insulating material. The tanks are preferably provided with pressure-gages 12 and valved inlet-pipes 13 whereby they may be connected with a suitable compressor.

In Fig. 5 is shown a form of my improved condenser with an inductance or a transformer and the spark-gap under pressure. The tank or shell 14 which may be of any suitable material as iron, brass, or aluminium, is provided with a removable top or cover held in position by bolts, the joint between the cover and

shell being made hermetic by a suitable packing. One series of plates 15 of a suitable metal as brass, or aluminium, are secured to metal rods 16, while the plates 17 of the other series which alternate with the plates 15 are secured to metal rods 18. These rods 16 and 18 are secured in disks 19 formed of a non-conducting material as porcelain, and suitably supported within the tank or shell. The transformer, which can also be used as an inductance by omitting a coil or set of coils, consists of coils 20 and 21, either of which can be used as primaries and the other as secondaries. These coils are arranged between non-conducting plates 22 and 23, preferably porcelain, provided with spacing-ribs 24 on their inner surfaces. One of the plates is supported in any suitable manner by the top plate of the condenser, being arranged in an opening in the top porcelain disk 19. The coils, which are preferably made of hard drawn brass or phosphor-bronze, are secured at one end to one of the non-conducting plates and the opposite ends are secured to the other plate 22 so that by shifting the top plate 22, these coils may be extended or compressed, thereby varying the inductance of the secondaries and primaries while maintaining the ratio of transformation practically constant. A convenient means for shifting the plate 22 consists of a threaded rod 25 rotatably connected to the plate and extending through a threaded opening in the top or cover and provided with a knurled head. It is preferred that a scale *a* should be arranged in operative relation to same and indicating-point on the threaded rod, as its head, so that the wave length produced by the adjustment of the transformer or inductance, may be read off the scale. It will be understood that by omitting one of the coils as 21, the other coils 20 may be employed as an inductance. The spark-gap is formed by terminals 26 and 27, one which consists of a disk and the other of a small point. The disk is attached to a threaded rod 28 extending down into a glass tube 29 and the point is carried by a post or standard 30, secured to the upper disk 19 and extending up into the glass tube 29, which communicates with the interior of the tank so that the spark-gap is subjected to the pressure in the tank. Electrical connection with the parts of the apparatus within the tank is had by conductors 31 extending through plugs 32 formed of non-conducting material and having tight joints with the cover of the tank. It is preferred to place in the tank a vessel 33 containing a suitable chemical, as lime, for absorbing any nitrous fumes which may be generated by the spark. The advantages of this form of oscillating circuit are many.

First. It is very compact as in a single tank one foot in diameter and five feet long may be placed as much capacity as can be obtained from ninety pieces each fifteen inches square and twelve inches high, such as are now ordinarily sold on the market for condensers for wireless telegraphy.

Second. It is self-contained and the whole apparatus can be made ready for use by connecting the terminals.

Third. It is indestructible as nothing is used in its construction except metal and porcelain. If the dielectric breaks down it at once renews itself on the current, being brought to its original strength, and in fact it becomes stronger with longer usage, this being probably due to the fact that the percentage of nitrogen continually tends to increase until ultimately the tank contains nothing but pure nitrogen.

Fourth. It is unaffected by extremes of temperature.

Fifth. There is no dielectric hysteresis or brush discharge and apparently no losses of any kind, and almost any degree of resonance appears to be obtainable by its means.

Sixth. All objectionable noise is done away with, as the only noise from the discharge is a slight metallic tinkling when the spark passes, which is practically unobjectionable.

Seventh. The period of the oscillations and hence of the frequency of the wave produced, appears to remain absolutely constant irrespective of the temperature and other conditions so far as can be measured, *i. e.* to within about one-tenth to one per cent. as determined by the hot-wire barretter.

Eighth. The radiation for any given applied voltage and current is extraordinarily constant. It is a fact well known to workers in wireless telegraphy that it is very hard to obtain perfectly-uniform radiation or to obtain the same amount of radiation on one that is on another, owing to slight changes in the quality of the spark. It is a remarkable thing that with this form of apparatus an adjustment can be found where variations in spark length produce little or no variation in the amount of radiation and for this reason extremely satisfactory electrical measurements can be made by its means, more especially when used in connection with the selector device described in United States application Serial No. 254,129, the selector-terminals being worked electromagnetically after being placed inside of the compressed-air tank; this however, is not shown or claimed herein as it forms the subject of a separate application.

In Figs. 10 to 13 I have shown desirable modifications of my improved apparatus. The condenser-plates 34 and 35 are alternately secured to rods 36 and 37 secured to insulating-supports 38 within the tank or shell 39. In the construction shown in Figs. 10 and 11, an inductance formed by coiling wire 40 on a drum 40^a of insulating material, is supported

by a rotatable shaft 41 extending through a stuffing-box into the tank or shell. A contact-point 42 is adjustably mounted on an extension of one of the rods, to which one series of condenser-plates is attached. This point is in constant contact with the coil 40 and by rotating the drum its position can be changed, thereby varying the inductance. The spark-gap is formed by terminals 43 and 44, one being connected to one of the condenser-plates and the other to the inductance.

In Figs. 12 and 13 the inductance is formed by two series of rings 45 and 46. The rings of one series adapted to project between those of the other series. The rings of each series may be formed integral with each other as shown in series 46 or independent of each other as shown in series 45. The rings are adapted to be shifted relative to each other so as to vary the inductance. In the construction shown one series of rings is secured to a plate 47 of insulating material supported on the rods 36, 37 and the other series of rings is secured to a similar plate 48 attached to a movable rod 49 extending through a stuffing-box into the tank or shell. In this construction the terminals 49 and 50 forming the spark-gap are secured respectively to one of the condenser-plates and the insulating-plate 47, the latter terminal is electrically connected to the inductance.

It will be understood that compressed gas may be used in combination with other dielectrics, as for example, in Fig. 10 I have shown the condenser-plates 34 and 35 insulated from each other by dry paper. The employment of compressed air in connection with other dielectric improves the efficiency of the latter, as it seems to stop or prevent static leakage, with its accompanying disintegration of the dielectric.

I claim herein as my invention—

1. A condenser having in combination the two conducting surfaces and a dielectric of gas under pressure.

2. A condenser having in combination two series of conducting surfaces or members, the surfaces of one series alternating with those of the other series and a dielectric of gas under pressure.

3. A condenser having in combination a tank or shell, two conducting members arranged in the tank, and a dielectric formed by gas under pressure.

4. A combination with a tank or shell of two conducting members, spark-gap terminals, an inductance or transformer, said part being arranged within the tank or shell and surrounded by a gas under pressure.

5. The combination with a tank or shell of two separated conducting members and spark-gap terminals arranged within the tank or shell and surrounded by a gas under pressure.

6. The combination with a tank or shell of two separated conducting members, spark-gap terminals arranged within the tank or shell and surrounded by gas under pressure and means extending from the tank for adjusting one of the spark-gap terminals.

7. The combination with a tank or shell of two separated conducting members, an inductance or transformer and spark-gap terminals arranged within the tank or shell and surrounded with gas under pressure and means external of the tank or shell for adjusting the inductance or transformer.

8. An oscillating electric circuit and a frequency-determining element surrounded by a gaseous dielectric under pressure.

9. The combination of two conducting-surfaces and an inductance or transformer, said parts being surrounded by a gaseous dielectric under pressure.

10. The combination of two conducting-surfaces and two dielectrics, one of which is formed by a gas under pressure.

In testimony whereof I have hereunto set my hand.

REGINALD A. FESSENDEN.

Witnesses:

THOMAS P. BROWN,

JESSIE E. BENT.