DeForest Notes

June, 1912—February, 1914

DeForest Notebook Records.

Herein petitioners have printed the DeForest and Van Etten laboratory notebook entries which have a bearing upon the question when DeForest invented the "feed-back oscillator". There are three groups of notes (1) those of the June, 1912 experiments with "gas action" oscillations, which include the brief entry of April 17, 1913, recording what DeForest claims to have been a reduction to practice of this invention, (2) those of the August, 1912 telephone repeater experiments, which have been relied on chiefly by respondents to establish either conception or reduction to practice of the invention, and (3) the experiments of February, 1914, which respondents have attempted to explain away, which the court below ignored, but which, petitioners contend, and the Circuit Court of Appeals for the Second Circuit found, show just when and how DeForest, after three weeks of diligent experiment, finally stumbled upon this invention.

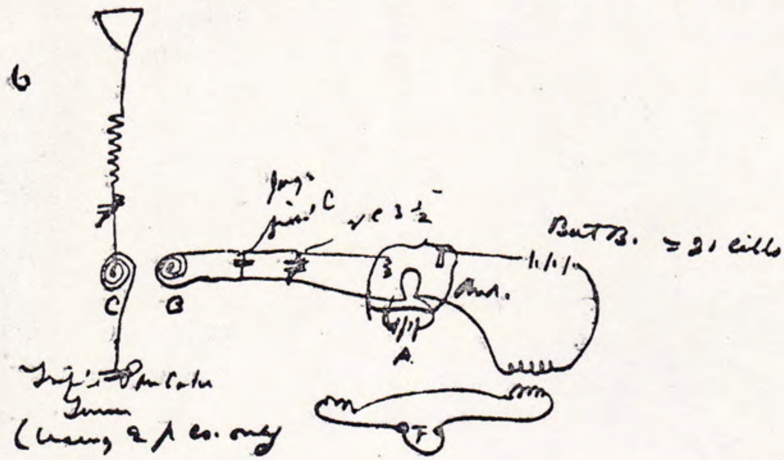
To make these notes understandable to the Court, abbreviations have been spelled out. Otherwise, they are as they appear in the record, including the diagrams. The record which these notes make, is wholly inconsistent with the contentions of respondents and the findings of the court below. Moreover, the notes reveal the character of DeForest's work, conducted purely upon the trial and error method, with no knowledge of principles, no ability to reason from the particular to the general. They show how entirely without support is the conclusion, which is implicit in the decision of the court below, that DeForest was able to reason, without experiment, from the thing which was not the invention to the thing that was.

NOTES OF JUNE, 1912.

Notes showing gas action effect.

June 21—(35 R. II, 1213)

"Beat" or High Frequency Notes from Audion (San Francisco sending on undamped continuous oscillations).



TRIPLE PANCAKE TUNER (USING 2 PANCAKES ONLY).

By placing the two pancakes about 4 inches apart I got fine note from Audion A by adjusting the A circuit rheostat. Variable condenser 3½ at 89°.

When moved this to 76° the note became *much higher* estimated ⅔ octaves or such a matter.

Later—could change the note on a large range of *quality* as well as pitch—by

(1) Altering distance between pancakes;

(2) Changing either primary variable condenser or secondary variable condenser;

(3) Altering resistance of audion battery A or potential of battery B.

(The setting of Audion Rheostat is critical and after the note is lost it is sometimes hard to regain).

(35 R. II, 1214)

The "lightning" static generally produced a similar kind of squeak, just at the beginning or end of a long, moderately strong, drawn out discharge.

The *highest note* lay in the middle between descending scales on either side.

This would indicate that it is not a purely "beat" phenomenon for then the frequency should *diminish* as the two circuits approached resonance.

Rather one of *intensity* of effect on the Audion, causing it to squeal; the pitch and quality of the squeal depending on the *intensity* of *impulses.*

I couldn't get this squeal at all on another Audion.

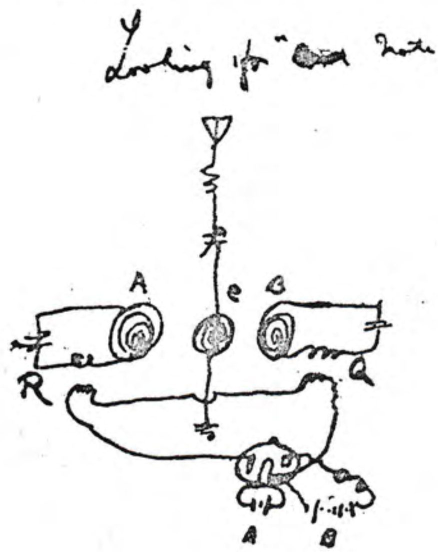
June 23—

Today I had difficulty in getting the squeal on that Audion. Couldn't get it at all on two other bulbs. Later —couldn't get it at all on the first Audion.

The effect is evidently due to some

LOOKING FOR "BEAT NOTE" (35 R. II, 1215)

1

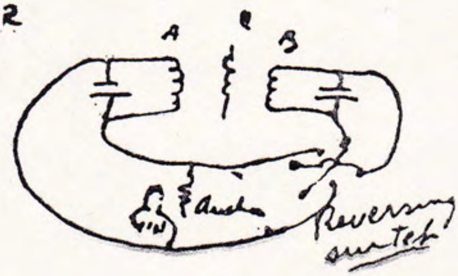


(35 R. II, 1215)

Couldn't make this go because coupling of Audion circuit at R and Q was too loose.

Hence tried direct connection:

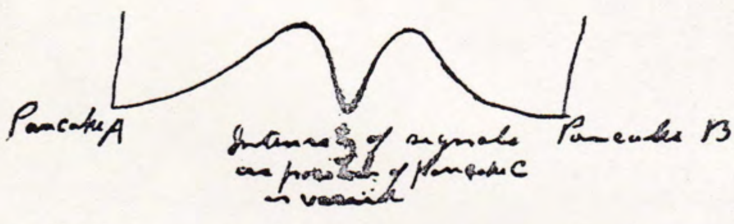
2



With this ckt obtained the following peculiar results as regards intensity of signals when both A and B were tuned to San Francisco wave length:

With the secondary circuits A and B opposing.

3



These humps become sharper and sharper as the pancakes A and B are brought nearer together.

Note of June, 1912, with footnote of April 17, 1913.

(35 R. II, 1216)

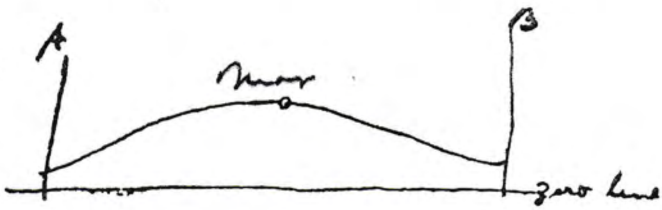
But I was quite unable to get a "beat note" by any manner of careful adjustments. Apparently therefore the effects on the Audion are integrative.

With A and 8 aiding get: *

The further A and B are separated the flatter the maximum becomes—soon zero line becoming *concave* and will be zero if A and B are far enough separated.

The depression near A and B (in both figures) is due to some damping effect of the two pancakes so close together.

4



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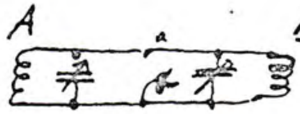

For very loose coupling between A B and C the effect of B on C is entirely due to "conductive" effect of B on the A circuit, or vice versa. But when B is *tuned to A* it has no effect on A, and when it is *not* so tuned it acts to throw A entirely out of tune with the transmitter (or antenna circuit C).

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*Apr. 17, 1913—This day I got the long looked for beat note—from a simple 2 pancake cabinet and series circuit (load coil on top of cabinet) *but only by careful adjustment of Audion Battery A Rheostat.* Then by adjusting loose coupling, variable condenser 1 and variable condenser 2 got the real "heterodyne" phenomena.

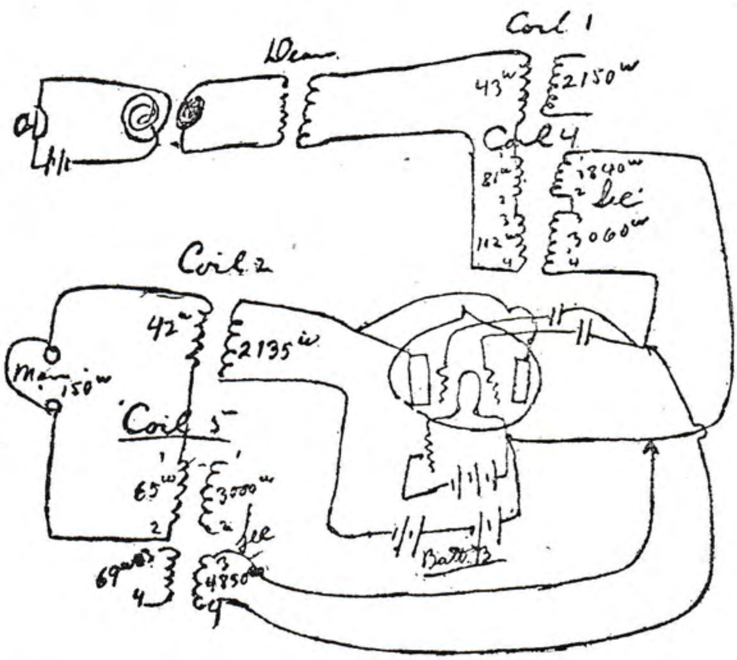
NOTES OF AUGUST, 1912.

Van Etten first August 6th note, held by the court below to constitute a reduction to practice of the "feed-back oscillator" invention.*

August 6—(35 R. II, 1194)

Lacking 2 audions complete with separate battery B and battery A tried the following circuit and found that the watch ticks came through although they were not amplified—a slight loss probably.

7



*This entry was recorded by Van Etten in his own personal notebook, and was not copied into the DeForest laboratory notebook, in which all matters of importance were copied.

When 3-4 of coil 5 is connected as indicated to 1-4 of coil 4 get a beautiful clear tone in phones.

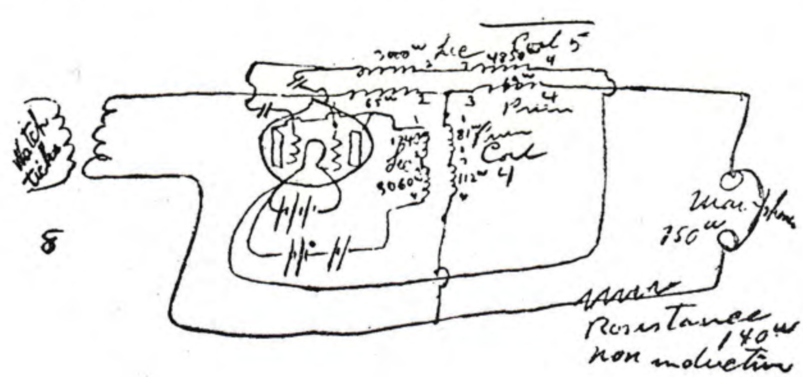
(35 R. II, 1195)

This tone weakens and raises in pitch as battery B is increased from 15 to 18 cells. This tone can be kept out by placing magnet about the audion and then the watch ticks come through as before. It also tends to disappear as the number of cells in battery A is increased. This phenomenon apparently similar to the "howl" produced in an ordinary common battery telephone when receiver is placed against transmitter but nevertheless as shown by variation of number of cells in battery B and by magnetic wiper is also intimately associated with audion.

Van Etten second August 6th note.

August 6—(35 R. II, 1196)

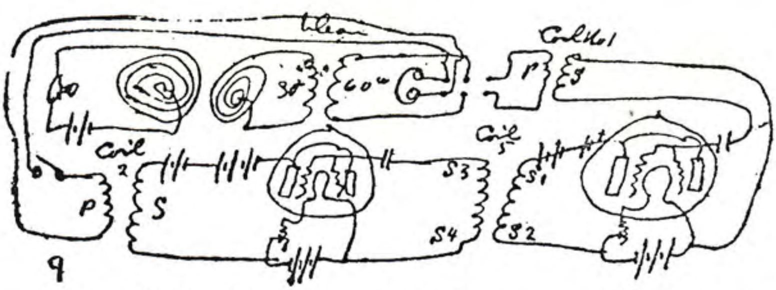
Tried following circuit but it was NG. Could not make it boost *at all*. Could only make it *howl*.



Van Etten's personal entry of the successful telephone amplifier experiment of August 29.*

August 29—(35 R. II, 1208)

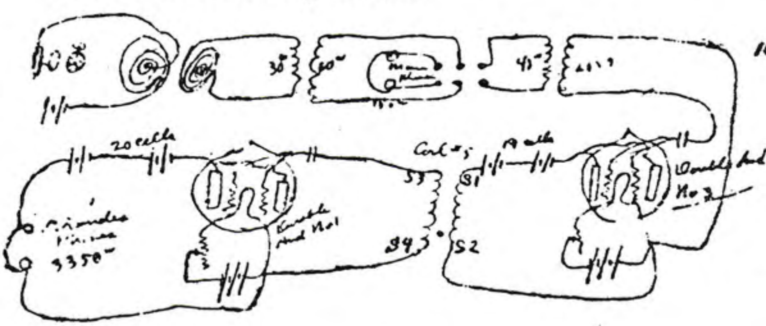
Set up 2 audions in tandem as boosters and secured a most wonderful amplification.



Through the 2 audions could hear yourself breathing when standing across the room from transmitter if pancakes were loose-coupled. Arranged coupling so could barely hear watch ticks when directly connected to Manhattan phones with shunt of *177* ohms across phones. Could then hear watch ticks through double audion booster with shunt of only *3* ohms across the Manhattan phones!

Van Etten's record of the same August 29 entry, as copied into the DeForest notebook (35 R. II, 1217)

Tested the following circuit:



*The successful part of this experiment has nothing to do with the invention at issue.

(35 R. II, 1217)

With this circuit the pancake coupling could be loosened until the watch ticks positively could not be heard at all in the Manhattan phones but throwing the switch the watch ticks would be heard loudly in the Brandes phones.

With pancakes one on top of the other the sounds in the Brandes phones were 25 to 50 times as loud as the sounds in the Manhattan phones.

Reversing the connections to the secondary winding of Coil #1 made all sorts of musical notes in Brandes phones, then reversing connections to one coil winding of Coil 5 the musical notes, whistles, etc., are gone and the ticks came thru as before. When coils are so connected up that a whistle or hiss is produced all sorts of whistles and musical notes of various pitches and intensities can be produced by putting very small capacities —such as the capacity of ones body or from thumb to finger—between ground and grid, wing or filament or by crossing any or either or all of these points thru small capacities (35 R. II, 1218).

When connected so as to produce musical notes or whistles these could be wiped out and the ticks brought thru again as loudly as before by placing a strong magnetic field on Double Audion #3.

Then put in switch so could connect 2nd Audion to secondary side of Coil No. 2 instead of to Brandes phones. Then connect Manhattan phones to primary side of Coil 2. Then with a variable shunt connected across the Manhattan phones varied the coupling and the shunt until could just hear the watch ticks. Now connected Dean coil secondary direct to Manhattan phones and increased shunt resistance until again could just hear the watch ticks.

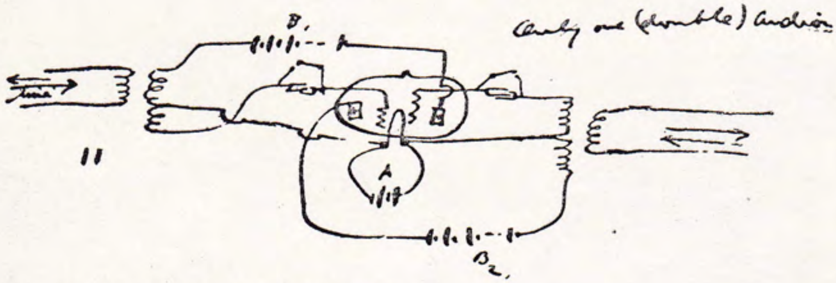
Result—WITHOUT two Audion boost—177^{w} shunt*

WITH two Audion boost—2.9^{w} shunt*

DeForest August 28-29th, 1912 entries.

August 29—(35 R. II, 1219)

Tried the following

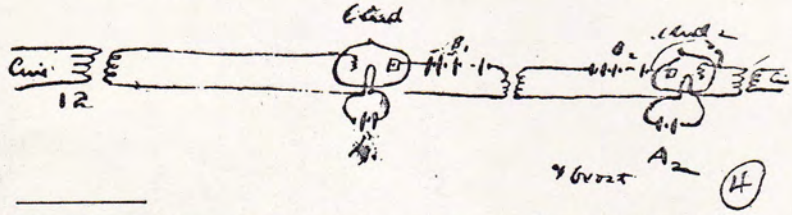


Only one (double) Audion.

for 2-way "repeater"[1]

Found the arrangement no good Λ as in one or the other direction the Audion would sing or whistle or else become completely paralyzed. But this double grid arrangement boosted the sound when used for "one way" only.

Then tried:



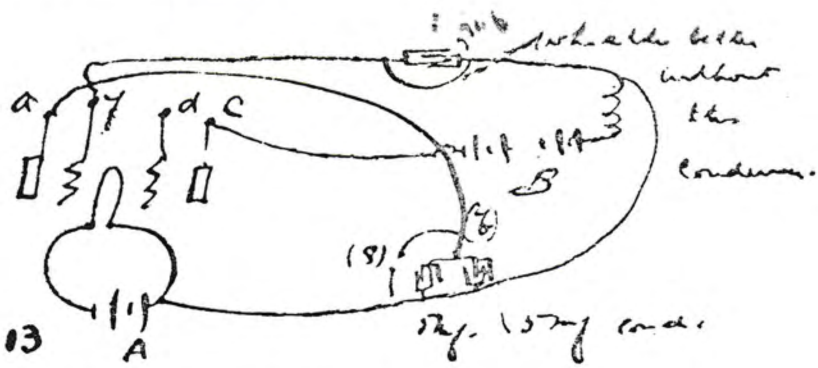
*These figures record the amount of amplification produced, according to the method of measurement used.

[1]These words are inserted above the line, as if added later.

This circuit was n. g. It will "talk" and boost in one direction (from right to left as here shown) *provided* grid and wing of Audion 2 are connected together—but not through the gas gap; and it will talk but not boost in the other direction when Audion 2 is thus grounded.

(35 R. II, 1220)

Investigated further this auto whistling quality of the double audion:



Whistles better without this condenser.

Connected as shown—got a persistent whistle when battery (A) and wing (a) were direct connected. This whistle was much reduced in intensity by inserting the 5 micro-farad condenser as shown, altho whistle at *first,* when first opening the short circuit (S) or first connecting the condenser to (a) was loud, gradually fading down to a minimum.

Added a second 5 micro-farad condenser in parallel. This did not change the pitch at all, but increased the minimum sound and doubled the duration of the decay. This was the same pitch of note as when these condensers were short-circuited. This shows that the period of this oscillation is quite independent of the electrical constants of the circuit.

The singing was more easily started if contact is made and broken at (a) rather than at (b) for then the steepness of the surge appears to be greater for it sets up a vibration which is continuous, self-sustaining (35 R. II, 1221).

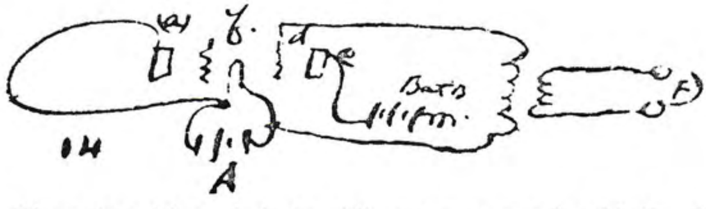
But if contact (a) is kept closed and (b) is made then the duration of the whistle is only for a brief time, the duration depending on the capacity of the condensers.

Contacting (a) to (c)—No whistle

" (a) to (f)—Very faint or none

" (a) to (d)—Good whistle

Next interchanged the 2 grids. Thus:



Then touching (a) to (f) gave a good whistle, but this was by no means as easy to get going as when I connected battery B to (f) and (a) to grid (d). (As one would suppose, from consideration of the migrations of ions from filament to wing (c).

The pitch of the whistle depends on the conditions in the Audion itself—the intensity of light, the battery B voltage, etc., but not on the electrical constants of the circuit.

Putting the hand on (d) *decreased* the pitch by one octave, but wetting the fingers, *i.e.,* making a good contact, stopped the whistle entirely showing the existence of a "rectifying" tendency or assymetry in the phenomenon.

But increasing the heating current *gradually* lowered the pitch, through a complete octave, or more.

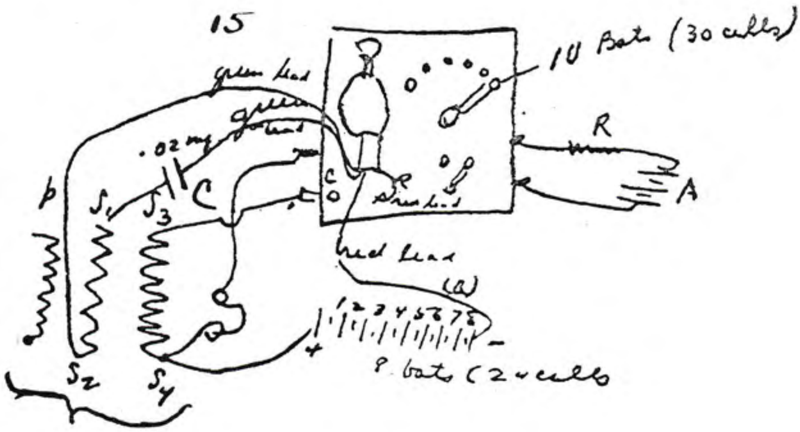
DEFOREST FEBRUARY, 1914, NOTES.

1391 Sedgwick Ave., N. Y. C. (35 R. II, 925) *Feb. 5-14*

Trying for squeal or whistle—to get this in a critical state when the *right* spark frequency will start it and other frequencies will not.

First followed the directions on preceding pages—(Palo Alto notes)—but without *any* results—couldn't get one bulb alone to squeal.

Used a double grid and plate bulb, with distinct leads—in "R J-5" Box.



With this circuit I adjusted Rheostat R.

This coil a standard Type 1 amplifier coil.

Keeping filament circuit same and B switch on last point 6—got high, faint squeal and faint, very low hum with A on 8.

A on 7—much louder but higher pitch still very low, (like cat purring)—A on 6 about ½ note higher; A on 5½ note higher, and so on up to A on 2.

(35 R. II, 926)

But for A on 1, that faint high note (whose frequency had remained the same as I judged through and back of all those low notes) became——

Reversed the polarity of Battery B_2 and at low heat of filament got "oboe" note pitch *increased* as number of batteries in between S_4 and wing increased.

As a general rule increasing Battery B voltage *increases* pitch—and increasing A circuit *lowers* it.

I often got such low frequency discharges that it sounded exactly like a static arc sparking. Again got slow and measured succession of faint bell-like sounds, each of which ends in a "click", like a falling block of wood.

Or the bell sounds break up into a short series of bubbles, which again fade into the faint bell-like sound. The heat of filament seems the most critical element here.

The low (composite—oboe or unclear) sound—appearing at *red* heat of filament is less constant than the high clear persistent note when filament is normal brilliancy. Putting my hand on condenser C drops this note one octave (35 R. II, 927).

(a) 2 micro-farad condenser not necessary. Short circuited acts just the same *provided* condenser C is in—but require one or the other. Similarly if C is in circuit can cut out B and merely lower the note a trifle.

(c) .02 micro-farad condenser makes no appreciable difference in pitch or volume.

(e) With this in connection the pitch is much higher or else is a "wobble".

Short circuiting p_1—p_2, s_1—s_2 or s_3—s_4—all kills the whistle.

It is important *which* grid is connected to s_2 and which to the point (S)—one *won't* whistle. Battery B_3 (to charge grids plus or minus) increased volume of sound. Wing W_1 *can* lead direct to S_4—but can *not* be charged with a considerable negative Battery B_2 voltage. But when W_1 is connected to the *positive* terminal of B_2 the pitch drops slightly as positive voltage is increased. When this is made positive by 2 to 3 cells or more so by regulating voltage of B_2 I can make the tendency to whistle greater or less, i.e. if W_2 is connected to the *negative* end of B_2 and S_4 to the *positive* end I can find a place where it will not sing, (or by keeping fixed on B_2 and varying A rheostat) (35 R. II, 928).

(In any case can alter pitch here considerably by means of the A rheostat above.)

Reversed W_1 and G_1 with W_2 and G_2 and found that could again get the whistle when the wing that leads to battery 2 is next to the grid that goes to the condenser, but *not* otherwise.

Or in other words the wing going to S_3-S_4 coil must be next to the grid that is connected to the S_1-S_2 coil.

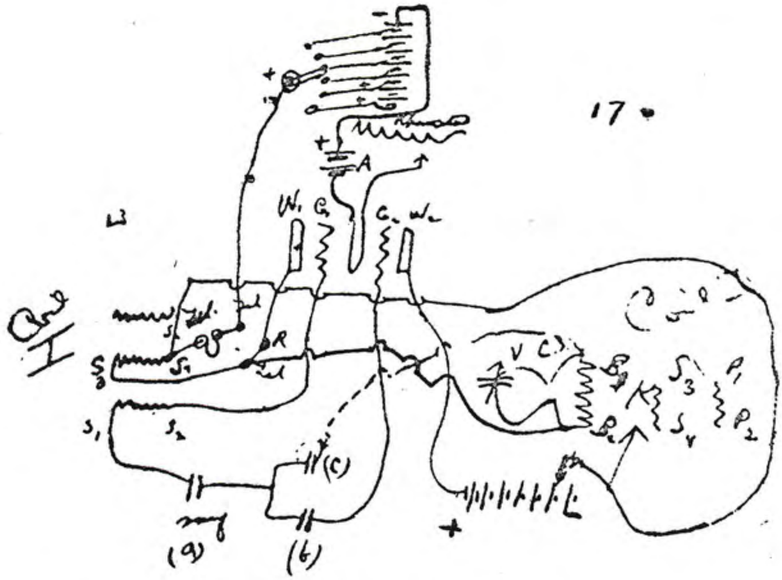
A most interesting phenomenon: (35 R. II, 929)

When B_2 is in circuit and above the whistle (W_1 being connected to the positive end of battery B_2—whether or not *this* is essential have not determined)—I can hear the bell sound due to vibration of plate or grid when I tap audion or even tap the table—hear it above the whistle.

But when I open this B_2 circuit and thus stop the whistle—this audion is perfectly dead to all such tappings!

Indicating that when the ions are kept stirred up, agitated by the whistling phenomena—the ionic "beams" are not so rigid and can vibrate to the jarring. (For it is hardly likely that the whistling phenomena actually makes the plates and grids less stiff in the gas.)

(35 R. II, 930)



In general short-circuit condenser (*c*).

Then if I also short circuit condenser (*a*)—get mixed sound—like oboe, running a very rapid gamut as A circuit is varied.

But if condenser (*a*) is in circuit and (*c*) circuit is opened entirely get very high note.

Made coil K circuit as follows: S_1-S_2 (of standard "Type 1" coil)—high note—"yep" "yep" "yep" in groups crying etc.—on low light—steady on higher heat.

Shorted P_1-P_2—much higher note.

(35 R. II, 931)

When I cut in condenser (*a*) and short condenser (*c*) then when I also short condenser (*b*) I get that slowly damped sound train—lasting a few seconds—then silence.

But this is ephemeral—and could not be again obtained.

Connected S_4 & S_3—no difference

Connected S_4 & S_2—much lower note

Connected P_1

Open the circuit entirely—very high note.

Put lead (*p*) on S_4—slightly lower note than on S_2.

Put (*p*) on iron *core* of the coil and got high note but lower than for open circuit.

Thus varying the capacity and inductance of this to W_2 varies the frequency by large steps.

But at all times regulating rheostat varies the pitch continuously (?)

Exception: When I put a .02 micro-farad across S_4 and S_2—then the pitch seems to be unchanged whatever the light of filament.

(35 R. II, 932)

Next put a variable condenser 3 in across the terminals of coil II and got a fine range—fine clear note with good heat and rasping "donkey" note (inharmonic) for a lesser heat.

Increasing capacity of variable condenser 3 now decreased pitch of note—through about 3 octaves.

At a lower note could get good imitation of violin note.

With high clear note could get octave drop and flute like quality by touching S_4 with the hand a greater difference of pitch thus obtained with finger is obtained when the capacity of variable condenser 3 is small—naturally.

February 5, 14—(35, R. II, 932-933)

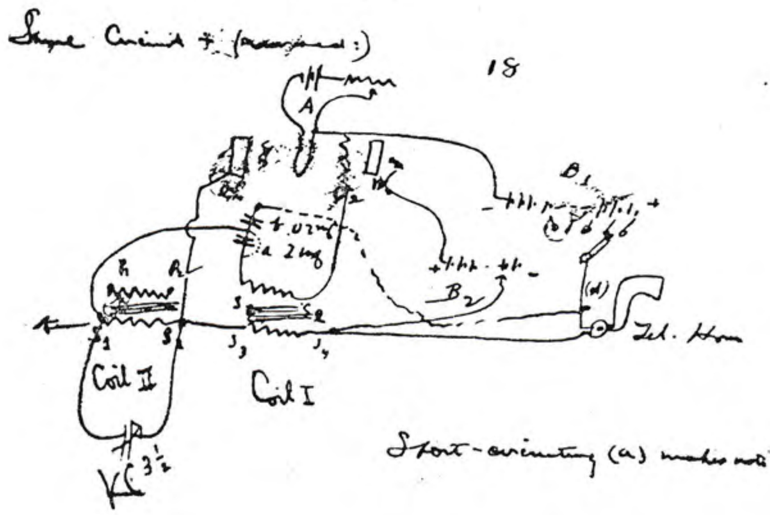
I have germ here of a beautiful and novel musical instrument. Note always louder when B_2 voltage is large up to 8 batteries (24 cells). Above this the sound gets still louder but is inharmonious.

If voltage of B_2 is made too great (say 10 to 15 batteries)—the audion seems to get harder and this sound is always unpleasant and unclear.

I find must *not* reverse S_1 and S_2 of coil I, nor connect either S_1 or S_2 with S_3 or S_4.

Best to cut out condenser (c) altogether.

Same circuit—(revised):



Short-circuiting (a) makes note higher and louder.

Open circuit at (k) gives higher note—and variable condenser varies this pitch—*i.e.* can do away with coil II entirely .

Can short (a) or (b) either—but not *both.*

When (K) is disconnected from coil II entirely I find that then connecting positive of battery B_2 to P_1 or P_2 of Coil II lowers and makes resonant this note.

N.Y.C. Feb. 10, 14—(35, R. II, 934-935)

Best to short circuit (a) and keep S_1 S_2 of Coil II in circuit.

Then if I short circuit condenser (b) all whistle ceases.

Try putting resistance across (b).

Did this and when (a) is shorted and Coil II is open I could *drop* the pitch by shorting condenser (b) and could gradually raise pitch simply by moving a wire on a graphite mark so as to slowly increase the resistance from 0 to infinitive.

I find that *both* grids are necessary. Neither alone nor with both joined together will give the whistle.

Connecting of G_2 with point (d) as shown gives a fine deep organ note. Which can be tuned by variable condenser 3½ as before. Putting a condenser in this connection raises the note, but still much less than with this connection off entirely.

Connected a .02 micro-farad condenser in series with 170000-200000 ohm (wet string) resistance—between W_1 and W_2 and could thus find a point on this resistance when bulb would just *not* whistle.

But this was with S_2 *open* at K. With this coil II in circuit this resistance (string) was always too little and stopped the whistle.

Success 1. Feb. 11, '14—(35, R. I, 935-936)

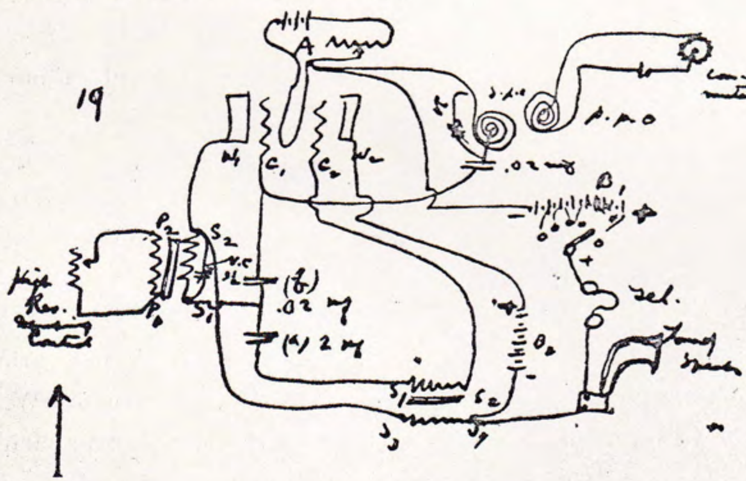
Connected S_1 at (K) so that Coil 11 was in. Then connected P_1 P_2 of this coil with a very short piece of wet string in the circuit—so that it just would *not* sing—

Connected a pancake for secondary of high frequency circuit and .02 micro-farad condenser in series, between G_1 and A+ (storage battery).

For full circuit see over:

But the critical pitch of this circuit is so low that this Ham-Beach motor will scarcely strike it, and at those low speeds is very irregular—so can't keep it going. But this shows that this audion selector circuit is very critical.

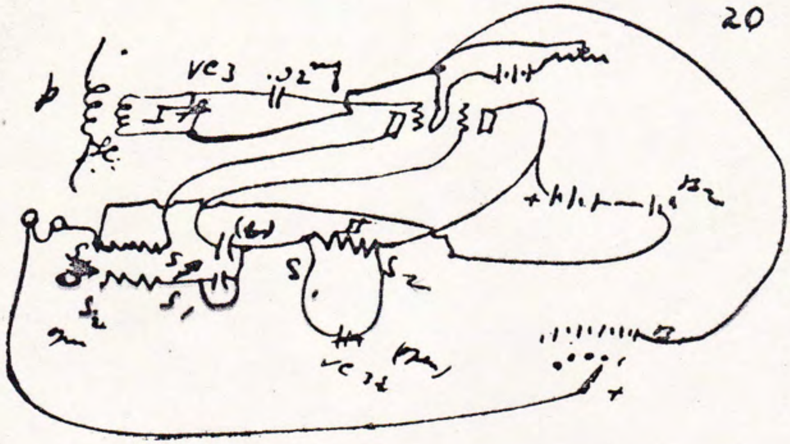
(I loose-coupled the high frequency impulse circuit to this secondary pancake so as to get weak response in the audion ordinarily. Then when the signals attained the *right frequency* the sound came out loud *into the room*—making a beautiful amplifier.)



This arrangement is critical.

Better to adjust battery A resistance.

Modified and got to *respond* to the arc (35, R. II, 937).



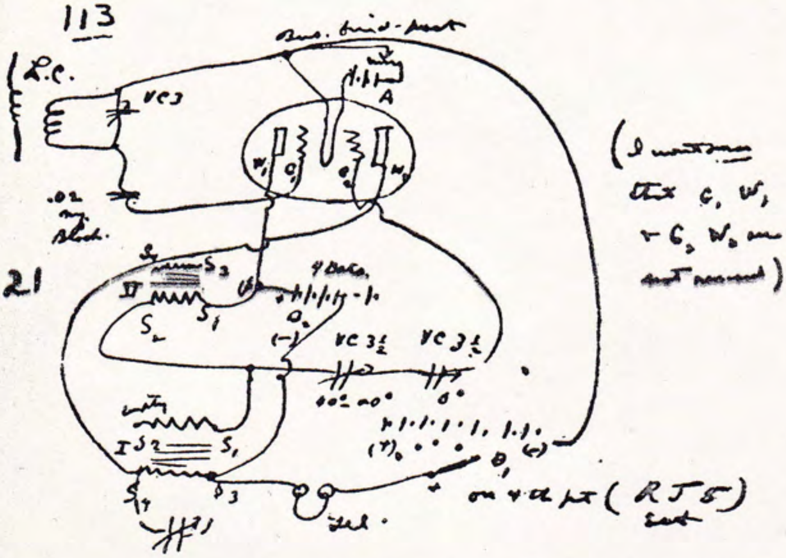
Now, by careful adjustment of B_1 and A_1 and loose-coupling (so that arc signals are not *too* weak)—get a very weak whistle all the time and a loud one when I is tuned to the arc. The variable condenser 3½ and S_1 S_2 of coil II determines the *pitch* of note.

The leakage of charge from condenser (b) makes the *hum periodic*—about 4 second period.

I avoided this (by adjustment) when I got the arc response above described.

Great Improvement— Feb. 14, '14

(35, R. II, 938)



I won't swear that G_1 W_1 and G_2 W_2 are not reversed.

Burn filament on very dull light.

Battery B_1 on 4th point.

Battery B_2 on 4 batteries (12 cells).

With this exact arrangement the arc produced a high clear musical note—laid on a *very faint* back ground of same pitch.

If the VC3½ condensers be not set pretty small (best as shown 0° and 40°)—this back ground note is too prominent.

Best—to date (Feb. 14) (35, R. II, 939)

Then I *reversed* G_1 and G_2—sing note ceased but (for battery B_1 on 1st point) got loud rasping "dry wood" sound—louder than the sing, and with *no back ground* at all.

Returned to arrangement of preceding page: Repeated results. Found that as B_1 is increased B_2 must also, in order to kill the "back ground" sound.

Can *lower the pitch* by increasing variable condenser 3½ between G_2 and S_2 (of Coil II—but this brings up the back ground disproportionately loud—so that no relief from sound occurs.

This series capacity (variable condenser 3½ plus variable condenser 3½) must be a very small one.

Next find I can do away with coil II *altogether*—and can lower pitch by putting finger on point (b)—but here again to do so increases the back ground.

But best to keep Coil II in.

Next added a variable condenser 3½ across S_2 and S_4 on Coil I (shown in dotted lines)—could now alter the note (up to 70° of variable condenser).

February 17—(35, R. II, 940-941)

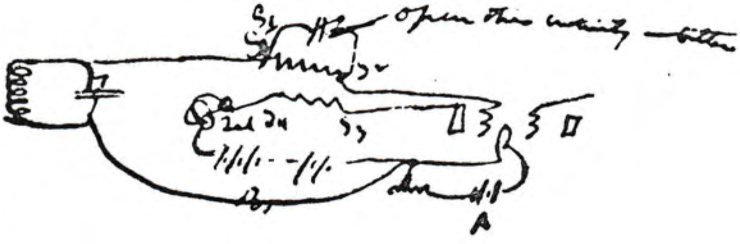
Substituted buzzer for *arc,* but found *no effect whatever* from its signals upon the whistle of the audion.

Next put variable speed interpreter in arc circuit and tried for "group-resonance"—but without any satisfactory results. The *back-ground* of tone through all this method seems to be the main difficulty.

Tried horse-shoe magnet in every position and with various lighting and battery B adjustments. Could increase sensitiveness of bulb on low heats and battery B but could always attain same sensitiveness without magnet by adjusting B and A circuits. Magnet did not help to distinguish signals—or quiet the "back-ground".

Repeated with another double glow bulb. Couldn't get the whistle to act as it did on the other—constant background.

However, tried this new and simplified circuit.[1]



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(Note—reversing S_3-S_4 gave *silence.*)

Could now get the desired effect with one grid but not with the other. (Could get the whistle however without difficulty with either.)

By properly adjusting battery B and especially rheostat A I got *either* effect—whistle for the signals and *no* back ground—or the reverse—no *sound* when secondary variable condenser was tuned to the arc. (Latter could only be used for "compensation" signals). Tried this on spark signals—no good results.

This is all too critical for use.

With this circuit could get "oboe" sounds and pretty scale by varying battery B voltage and also capacity of variable condenser around S_1 S_2. Raising B voltage *raises* the pitch now.

Increasing A circuit raises pitch—but note soon ceases if A is raised above the critical "high note" or beat state.

But on a larger A circuit raising B *decreases* the note:

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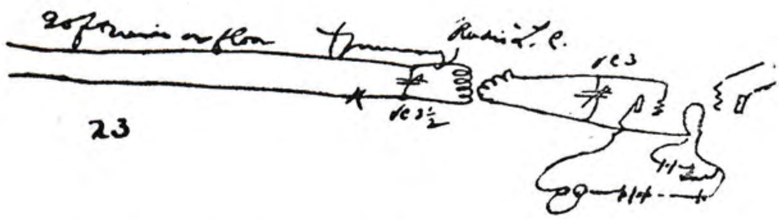
[1]This is the arrangement of the Van Etten Aug. 6, 1912 notebook entry, appearing for the first time in the DeForest notebooks.

Feb. 13—(35, R. II, 942-943)

"Beat" phenomena (to radio).

First cause—induction from 60 cycles through 20-foot wires on floor.

Second cause—audion (double wing and grid but *only* one pair in use)—battery B on 3rd point (important). A rheostat setting fairly critical (only).



Get high squeak and "muddy" sound—due to the 60 cycles. Made fine signals with the key at K.

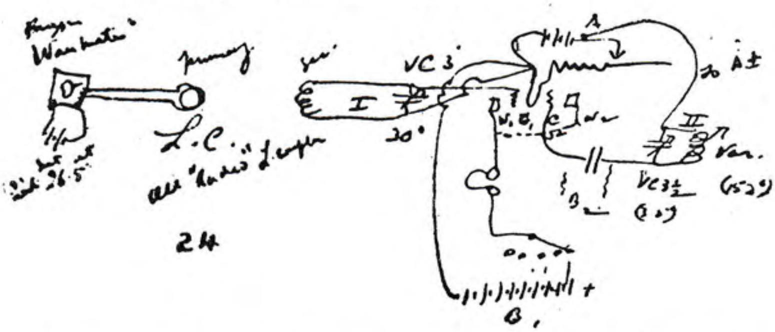
Either variable condenser or A circuit altered pitch of squeak—hiss. Could also get it from the alternating current in light circuits (or trolley wire) *without* the floor leads.

Can also get the hiss *without* the primary circuit at all—*i.e.* reaction of secondary circuits on the other audion circuits. (Am not yet sure whether the alternating current induction is to blame or not, but doubt it.)

When the *idle* grid and wing are connected up to the others the phenomenon ceases altogether.

The brighter the filament the less must be the capacity in tuned circuit (variable condenser 3) to give the hiss—showing that the degree of heat *increases* the period of the audion.

Next tried buzzer-excited tuned transmitter circuit very loosely coupled to receive (35, R. II, 944).



With this circuit the first time I found tuning in the II circuit.

Set I right and then tuning on II becomes very critical and all hum (even parasitic noises from buzzer) cease when II is detuned, no matter how variable condenser of I is moved. *But* when II is rightly tuned then moving variable condenser I all over scale makes but little difference—indicating that then II is the supply circuit, exerted from transmitter.

Found could substitute W_2 for G_2 to good effect—but either alone better than both in parallel.

Next joined W_1 and W_2 in parallel—greatly increased signals—and then the effect of G^2 and its parasitic circuit still continues equally good.

(The Block-condenser is necessary. But battery B_2 around this is very bad (either polarity)—for it polarizes the bulb—completely dead.)

So long as *either* I or II circuit is tuned the other can be detuned and still hear the buzz. But detune *both* and the interferences produced from the 2 circuits cause *complete* silence. (Use for static.)

Increase in sound by this circuit is about 4 to 8 times!

Reversed G_1 and G_2—keeping W_1 and W_2 together; results exactly the same—very satisfactory.

Feb. 13—(35, R. II, 945-946)

Repeated—using the *arc* as source instead of buzzer: Same results. Circuit II boosts signals 3-5 times.

Advantages of detuning both circuits also apparent.

Feb. 20—Resume of some preceding work (35, R. II, 946).

"Beat Phenomena".

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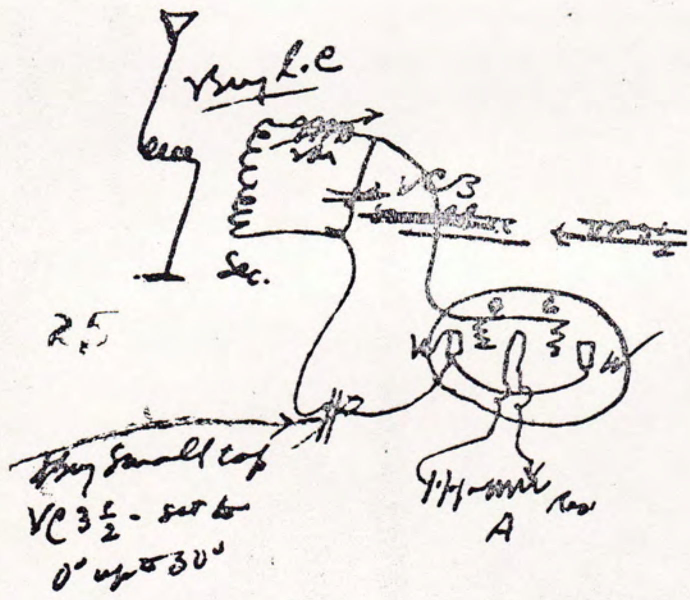
The "Grid-Wing" or "Grid-Plate" or Squealer-Circuit:[1]



[1]Here the ultra-audion circuit arrangement appears in the notes for the first time.

Very small capacity variable condenser $3\frac{1}{2}$ set to 0° up to 50°.

A high self inductance in secondary circuit absolutely necessary.

"Squeal" tuning on secondary variable condenser very sharp and therefore prefer to put a variometer in series with secondary coil so as to get non-critical note tuning.

This is much more (say 10 times at least) sensitive than the old circuit.

The blocking condenser must be small (0-50° on variable condenser $3\frac{1}{2}$) but is not critical.

When secondary variable condenser is very small and secondary inductance is large I get a very loud and *low*—frequency sound—the pitch of which depends very much on the B potential and A current and also on the capacity of the blocking condenser.

This pitch *rises* as B volts increase
rises as A current decreases
rises as blocking capacity decreases.

It is simply a periodic charging and discharging reactance.

Could get as low as 30 per second—"pop—pop—pop" by making the variable condenser 3 small (0°)—variable condenser ($3\frac{1}{2}$ (blocking) at 180° and then increasing A current. (This was with a large (inside 4 layer pancake) of .... cm. inductance.)

Putting a magnet across bulb *increases* rate of pop. With this arrangement and larger variable condenser 3 setting and with small blocking condenser (variable condenser $3\frac{1}{2}$ at 0) I got a soft "puck, puck" at *a certain setting* of the variable condenser.

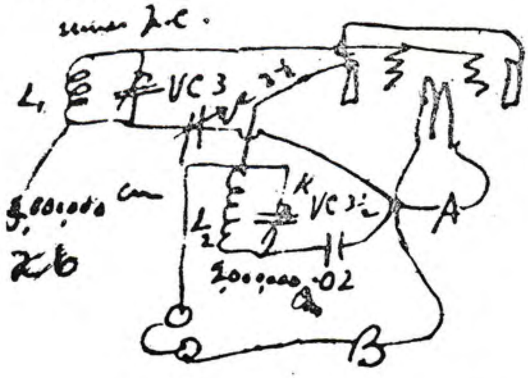
Increasing secondary variable condenser 3 decreases the rate down to a critical point where it ceases altogether.

But with another adjustment of battery B the reverse held. Position of magnet to considerably increase the rate of sound was rather critical.

Position of hand relative to the pancake was influential also. Also the rotation of bulb re the magnet.

Put both big inner and outer pancakes in series and found could vary the rate of popping by this huge variometer—rate *decreased* decidedly as pancakes were placed so as to *increase* the total inductance.

Feb. 24—(35, R. II, 948). Tried this "high frequency amplifier" circuit.[1]



Results—Arc transmitter about *twice as loud* as with the wing-grid circuit. The variable condenser K is not critical—and can get therefore quite low note.

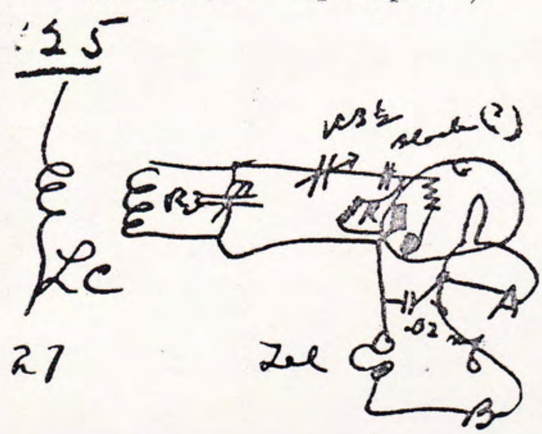
Must get L^1 and L^2 at right angles (see later repetition of this). Good also with wave meter 3000 meters—increase of sensitiveness. With variable condenser 3½ could

[1]It should be noted that seven days before, the Schloemilch and Van Bronk patent No. 1,087,892 had been issued, disclosing for the first time that the audion could be made to amplify high frequency currents. *Armstrong v. DeForest Radio Telephone & Telegraph Co.,* 279 Fed. 445, at 451 (The New York case).

get an almost singing sound just before capacity was made so large that the circuits "bubbled".

February 26—(35, R. II, 949-950) Spark Phone

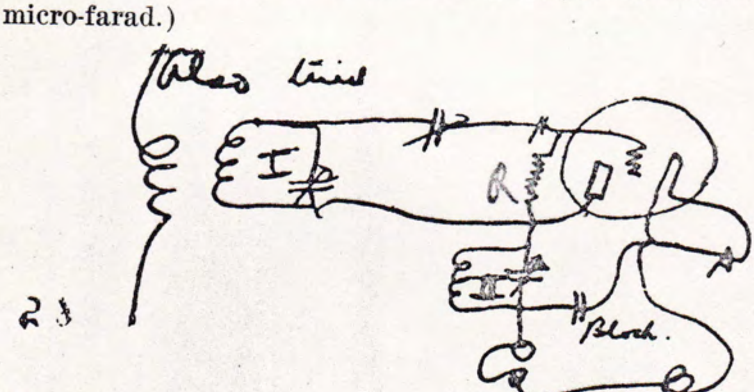
(Using 3000 spark phone)



R—is graphite resistance necessary here to prevent paralysis. Got excellent results. Speech clearer than *without the blocking* condenser.

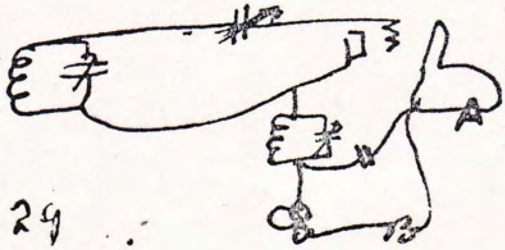
Also tried:

(Tried .06 micro-farad and found this better than .02 micro-farad.)



With this could get violent noise when I and II were tuned nearly alike, but could then hear absolutely *no one* at all.

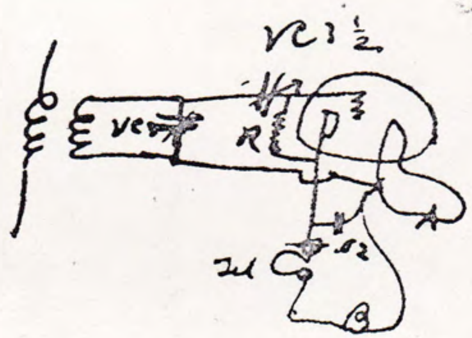
But for the *arc* this circuit was poor (for whistling):



Compared telephone reception also on this circuit:

R=Graphite resistance

30



Found this apparently just as good—but here also the blocking condenser and the graphite resistance were both necessary to get good speech, and the variable condenser 3½ quite necessary and loudest when set at *zero* °—but perhaps a little better, "rounder" speech when set at 50°. (of 'phone was about 750 meters).

For the arc whistle the following (with large inductances) was better than the plain "wing and grid" circuit:

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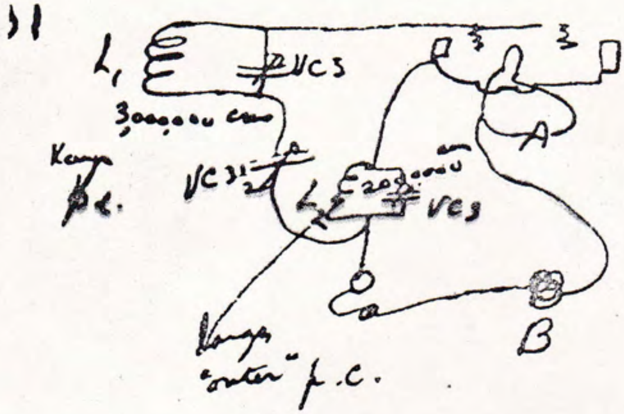
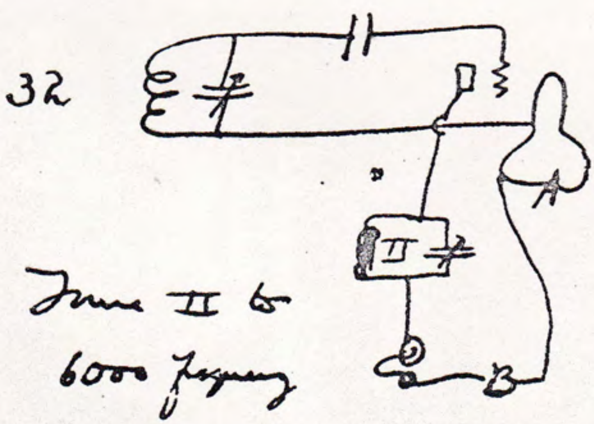


But later I cut out L_1 and variable condenser and then had merely the wing and grid circuit (with L_2 in the place of L_1).

Suggested (not yet tried—March 4): (35, R. II, 951)
For 3M—phone——



Tune II to 6,000 frequency so as to offer infinite impedance to the spark note.

(Same for the wing-grid circuit.)

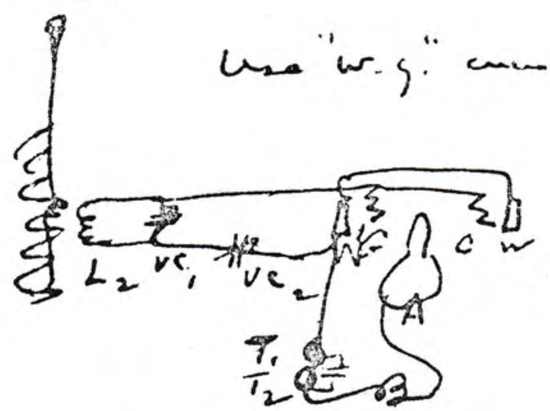
But I believe that the .02 micro-farad condenser around the phones will accomplish the same purpose and probably with less loss.

Feb. 27, '14—(35, R. II, 952-954)

FULL PROOF THAT THE AUDION ACTS AS A *generator* OF HIGH FREQUENCY CURRENTS (CONTINUOUS) :[1]

Use Wing-grid circuit ("Double" bulbs).
"P N" Type detector.
Cut off antenna altogether.
Light fairly bright.

33

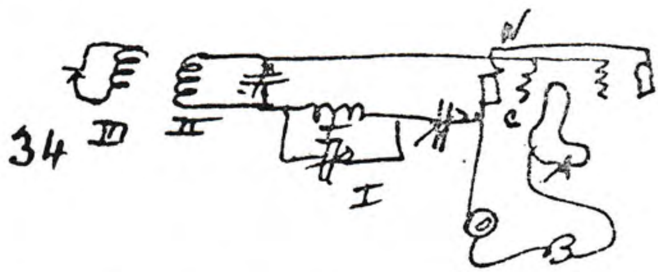


[1]This entry shows exactly when and how DeForest reduced the "feed-back oscillator" invention to practice, and shows that he had never before learned how to produce high frequency currents, or to control a system of audion circuits, with a feed-back connection, so that the frequency would depend upon the factors of the Thomson law.

Could get the hiss when variable condenser 1 was made such that the period of the wing-grid VC_1—L—VC_2 circuit was in resonance with the B—(bat.?) circuit.

Cut out one of 2 Telephones—and the setting of VC_1 to produce this hiss was different again—was fairly critical.

But when I used 2 oscillating (attuned) circuits and made and broke the tertiary circuit, got loud noise at certain settings.



Thus—When I and II were tuned alike then the make and break at III produced a loud click in telephones—showing the existence of silent, continuous high-frequency oscillations of *constant* amplitude[1] in the wing-grid Circuit.

Put a buzzer in the antenna circuit and heard perfect reproduction of sound in the telephone receiver attached to audion.

[1]DeForest had now, on February 27, 1914, attained the "great desideratum sought for in wireless telegraphy and telephony" in 1912, i.e., a continuously operating source of undamped electrical oscillations of high frequency. (See specification of DeForest application filed September 5, 1912, but abandoned, 35, R. III, 1415).

Then put *microphone* in this tertiary circuit and heard *perfect* speech in telephones on Audion. (Setting of (2) bulbs rather critical only.)

This shows conclusively that we have a condition of high-frequency oscillation generation in the Audion, given the proper A and B settings and the wing and grid and attached circuits.

Then tuned up another Audion receiver circuit and got good voice wireless transmission—the 2 antennas being 6″ apart![1]

There were probably a few milliwatts energy in transmitting antenna.

This last test was with the straight "wing-grid" circuit at transmitter (and receiver also); i.e., 1—cut out the "appended" or parasitic circuit I.

Can use the same Audion for *both* transmitter and receiver, and thus get Duplex telephone.[1] (Patent this.)[2]

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[1]The exclamation point should be noted.

[2]If there were no evidence against DeForest except this note, petitioners believe that it would be a complete refutation of DeForest's claim to an earlier date of invention.