The Papers of Thomas A. Edison

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Edison spent the summer of 1876 working hard in his new laboratory. His principal concerns were his acoustic transfer telegraph system and experiments with his electromotograph. Spurred by Alexander Graham Bell's epochal demonstration at the Centennial Exhibition, Edison also undertook new telephone experiments. In addition to these main lines of work, he continued his investigation of etheric force, designed several precision instruments, and experimented with the electrical and chemical properties of carbonized paper. Charles Batchelor worked in New York City for most of the summer, overseeing the electric pen business, but Edison and James Adams were sometimes joined in the laboratory by Ezra Gilliland and Edward Johnson.

Acoustic transfer telegraphy occupied the laboratory staff for the first part of the summer. In July they conducted tests on telegraph lines looped to Philadelphia and back. As August began Edison designed an "octuplex" (eight-message) acoustic transfer system, executing three covering patent applications later in the month. When octuplex instruments were ready in mid-September he tested them on the Philadelphia loop. At the end of June, Edward Johnson and Josiah Reiff witnessed Bell's telephone demonstration at the Centennial. Stimulated by their reports, Edison, assisted by Gilliland and Adams, began more intensive experiments in this avenue of acoustic research. Using different materials and configurations of diaphragms, different sizes and numbers of resonant tubes, and alternative arrangements of contact points, the laboratory staff transmitted vocal and musical sounds with vary-
ing success. According to Edison, James Adams conducted most of these experiments, using "any person who happened to be about to do talking upon instruments that [Adams] had constructed."

At the end of July, Edison received a shipment of electrical instruments from England. He began using them immediately and soon was comparing them to instruments of his own design. Among Edison's designs were mirror galvanometers using his electromotograph. This marked the beginning of renewed experiments with the electromotograph, some of which were soon directed at the old problem of finding a repeater that was sufficiently fast and sensitive for the automatic telegraph system. By the second week of August they were testing an electromotograph repeater on the Philadelphia loop. Edison also considered using the electromotograph in a system for high-speed retransmission of Morse messages that were to be recorded on a newly conceived perforating instrument.

The most expensive item in the English shipment was a set of resistance coils. In an effort to make their own electrical resistances, the laboratory staff baked many different kinds of paper to produce strips of carbon. Edison also thought of using carbonized paper for such things as battery carbons and chemical crucibles and carried out extensive experiments toward that end.

The electric pen became an international business when British businessmen John Breckon and Thomas Clare bought the rights to Edison's British patent and established the Electric Writing Company. Their agent, Frederic Ireland, was in the United States in July to consummate the deal with Edison, and on his return they established a London office to sell the pen. By early August Batchelor began shipping pens. Ireland, who became general manager of the Electric Writing Company, also expressed interest in acting on Edison's behalf for the sale of electric pen patent rights on the Continent.

During the summer the laboratory had its first prominent visitors. In early July, Ernst Fleischl, a Viennese scientist interested in electricity, visited Menlo Park. Later that month Sir William Thomson, fresh from judging exhibits at the Centennial Exhibition, spent a day at the laboratory.

Edison had a steady income from his May contract with Gold and Stock and Western Union's support for his acoustic experiments. More important, he received over $6,500 from the July sale of the rights to his British electric pen patent.
By contrast, Edison's involvement with his brother's street railway in Port Huron continued to be an annoyance, as other principals tried to buy him out or to get him to take sides in management disputes.

Perhaps the most important personal event of the summer for Edison was the death of his long-time friend and mentor, Marshall Lefferts, who died en route to the Philadelphia Exhibition. Edison never recorded his reaction to Lefferts's passing, but he undoubtedly felt his absence. 11

1. U.S. Pats. 185,507, 200,993, and 235,142.
2. About this time Elisha Gray was in New York demonstrating his own quadruplex system between New York and Philadelphia. Doc. 786 n. 4.
4. Edison later claimed that he had Gilliland and Adams begin making telephone experiments about May 1876. Doc. 772 n. 2.
5. The notebook in which Adams recorded these experiments was lost on his death in England. Edison's testimony, TI 1:37-38 (TAEM 11:39-40).
6. On the problem of automatic telegraph repeaters see TAEB 2:284 n. 4, 463 n. 1. For Edison's earlier experiments using an electromotorgraph repeater for automatic telegraphy see, for example, Docs. 573, 604, and 605.
7. The importance of resistance measurement to electrical technology and science is discussed in Hunt 1992.
8. See Doc. 829 n. 11.
9. See Doc. 925; and Serrell to TAE, 23 June 1876; TAE to Breckon, 29 June 1876; Ireland to TAE, 8 July and 15 Aug. 1876, all DF (TAEM 13:1032, 1035, 968, 969).
10. An undated memo lists the costs of the British, French, and Belgian electric pen patents (for which Serrell billed Edison on 28 June) and subtracts them (and other miscellaneous expenses) from $10,000. Edison, Batchelor, and Adams split the remaining $9,036 as per their agreement (Doc. 637), Edison getting $6,578, Batchelor $2,214, and Adams $244. DF (TAEM 13:952, 1034).
11. Edison purchased a portrait of Lefferts in October 1876. Cat. 1213:6, Accts. (TAEM 20:3).

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New York, July 5th 1876

Confidential

Dear Edison,

The death of Lefferts was fearfully sudden. 1
I heard it in Phila. on evening of 3rd.
I have written to Treasury. Dept to try & get Elliott instruments in free. 2

From Josiah Reiff

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July-September 1876
Will have reply I hope Saturday.

Months & months ago you assured me contracts were not needed between parties who intended to keep faith—Hence you will bear me witness I have never troubled you much. You simply know that as long as I had money, Newark Shop profited by it. When people invest the Capital we have spent, some return is expected.

You know I have not profited personally to extent of one penny in 5 Years. I have spent over $170,000 cash, without interest. You have often told me, you looked forward to the time (regardless of outcome of auto) when I should be your partner & sort of general agent with ½ interest—

I am now ready to devote myself exclusively to it, on some fair understanding

You have been annoyed during last five years, but your brain has been tremendously developed. You have had wonderful experiences—You have lived & accumulated considerable property, besides larger interest in Patent yet unsold. Where am I?

Thos. A Edison Knows what is right He has promised to stand by me & by the parties in London. Yrs  J C Reiff


2. Edison had ordered over $450 worth of instruments from Elliot Bros, in London, including three kinds of galvanometers, a set of resistance coils, and a condenser. Shipped to Edison at Reiff’s address on 16 June, they arrived in New York on 28 June with $180 import duty due. The import duty was paid and the instruments picked up 27 July (Elliot Bros. “Catalogue of Electrical Test Instruments,” Catalogues, Electrical and Telegraph Instruments, Library, NjWOE; bills and receipts, 76-002, DF TAE⑩ 13:863, 865, 870, 881). At this time the import duty on "philosophical and scientific apparatus" was 40% ad valorem unless "imported in good faith, for the use of any society or institution incorporated or established for philosophical, educational, scientific, or literary purposes..." (The wording is from the Tariff of 1870 [U.S., Statutes at Large, vol. 16, “An Act to reduce Internal Taxes, and for other Purposes,” sec. 650]; the rate of 40% was established in the 1874 revision to that act [ibid., vol. 18, “Duties on Imports,” sec. 1383].)
3. That is, the American Telegraph Works, Edison and Unger, and Edison and Murray (see, e.g., Doc. 436).
TELEPHONY

Edison had been investigating acoustic telegraphy intermittently since mid-1875, occasionally using the voice as a source of sound, but his serious work on the telephone began in early July 1876 after Edward Johnson reported seeing Alexander Graham Bell's invention at the Centennial Exhibition. During the next seven months the laboratory staff pursued telephone research as a sideline, with James Adams the principal experimenter. The research picked up in early 1877, as Edison was negotiating a new contract with Western Union and Charles Batchelor began easing out of the electric pen business and returned to laboratory work. By the middle of the year the telephone was the principal focus of work at Menlo Park, and it remained so—excepting sporadic attention to the phonograph—until the next spring. Edison filed nine telephone patent applications in Washington during 1877, eight of which would eventually issue.¹

Edison's telephone work centered on the transmitter. In Bell's system, the speaker's voice produced vibrations in a metal diaphragm that was almost touching the core of a magnet. The diaphragm's motion created induced currents in the line wire, which was coiled around the magnet, and those currents recreated the vibrations of the voice at the telephone receiver. Edison believed such currents were too weak for practical work and approached the problem differently. His system had a battery-produced current on the line, and he sought arrangements where sounds would cause fluctuations in that current's strength. He was primarily looking for a dependable, stable way to cause maximum variation in the signal. In the course of his research he re-examined Bell's transmitter and other schemes—including make-and-break circuits—several times, but his main avenue of pursuit was variable-resistance (or variable-current) transmitters.

Edison's early transmitters changed the line current by having a vibrating diaphragm move a contact in and out of a liquid or shunt resistance coils or batteries in and out of the circuit. In October 1876 he first used carbon as a conductor in a transmitter, coating a hard rubber surface with plumbago and running the line current through the coating; as the diaphragm vibrated it moved a metallic surface that short-circuited more or less of the plumbago and so varied the current. By mid-February, when Batchelor rejoined the laboratory staff full-time, carbon was at the center of the transmit-
ter research, and for the next year Edison and his crew struggled to find the best way to take advantage of its electrical properties, particularly its sensitivity to vibration. They also had to explore all the other aspects of the transmitter, such as the diaphragm’s shape, size, fastening, thickness, and material; whether to use more than one diaphragm; the shape of the mouthpiece; the instrument’s overall design; its electrical connections; and the means of manufacture. They also studied various receivers, in the process inventing one that employed the electromotographe and which they used to receive musical transmissions in public exhibitions. And finally the line circuit itself became an important part of the telephone, as Edison used induction coils to boost the transmitter’s signal.

1. Edison wrote an account of his telephone research for George Prescott’s Speaking Telephone, Electric Light, and Other Recent Electrical Inventions which focused on the development of the carbon transmitter. A partial manuscript is in 78-005, DF (TAEM 17:180-196). Prescott went on to describe a number of Edison’s other telephone designs and later research. Prescott 1879, 218-34, 526-50.

--759--

*Technical Note: Telephony*

[Menlo Park,] July 6th 1876

Experiments with talking telegraph

Tried a piece of felt saturated with water salt & water and other chemicals

tried on a long Brass tube Brass Diaphram with magnet in front and Iron armature Pasted on to the Parchment get a good many words Plain such as How do you do

X (photographic transcript), NJW OE, T I 2, Edison’s Exhibit 3-10 ( TAEM 17:213). Written by James Adams.

1. Testifying in interference proceedings, Edison produced this sketch as evidence of a series of experiments begun in “February or March, 1876” that tackled the problem of “transmitting articulate
speech, using transmitters which varied . . . the resistance by various means in which water was employed or other chemical solutions" (TI 1:31-32 [TAEM 11:36-37]; see Doc. 736). Bell's lawyers used this sketch to argue that Edison had reached only a relatively rudimentary stage of telephonic technology by mid-1876 (TI 4:196-97, 200 [TAEM 11:802, 804]).

2. This is the transmitter. The felt is represented by the small dark rectangle at the right, held against a diaphragm at the end of the tube. The circuit (not shown) passes through the saturated felt and then through the receiver's electromagnet (cf. the fifth sketch in Doc. 765). Sound entering the tube from the left vibrates the diaphragm, intermittently compressing the felt and thus varying the current. A similar drawing exists from the previous day. Edison's testimony, TI 1:33; Edison's Exhibit 90-15, TI 2 (TAEM 11:802, 804).

3. This is the receiver (Edison's testimony, TI 1:32 [TAEM 11:837]). Edison had been using receivers much like this in acoustic telegraphy experiments since the fall and winter of 1875-76. Docs. 674, 675, 699; see also illustration, Jehl 1937-41, 1:75.

My dear Edison.

Treasury Deptmt advises me the law will not allow them to enter the Instruments free.

Be careful how you proceed with O1 in any matter.

When I see you I can tell you of a remark he has made about you within past 4 days. I dont think you owe him anything.

A&P evidently intend to be in position if compelled to pay by law to say auto is worth very little to them. They seem to be depending for future on Duplex.2

When you next come in, I want you to sign & swear to Custom House paper whole cost will be about $725 currency.

Yrs tr

J C Reiff


1. Western Union president William Orton; see TAEB 1:237 n. 1.

2. Reiff may have been responding to the following editorial in the Operator of 1 June 1876 (p. 7):

It seems that The Automatic is not a success. We have been informed that Mr. A. B. Chandler, secretary of A.&P. T. Co., was heard to remark that he could purchase eight sets of De Imfreville's quadruplex at the cost of four sets of the automatic, and that one set of the quadruplex could be repaired for ten or twelve dollars, while it would cost from one hundred and fifty to two hundred dollars per set to repair the automatic. If this be true, and the

New York, July 10th 1876 a

From Josiah Reiff

1876
opinion is concurred in by the other officers of the company, it will virtually do away with the automatic system, and telegraphers themselves will not be sorry, as the automatic is not looked upon with much favor by the fraternity.

As part of Atlantic and Pacific's defense in the patent infringement suit brought by Edison, Reiff, and George Harrington, President Thomas Eckert later claimed that the company began removing automatic instruments from its lines in the spring of 1876, although according to General Superintendent David Bates the system continued to be used at some offices until the August 1877 pooling agreement with Western Union (Eckert's deposition, for Final Hearing on Part of Respondents, Harrington v. A&P, Legal Department Records, NjWOE; Bates's testimony before the Master, 1:25–26, Box 17A, Harrington v. A&P). On Atlantic and Pacific's use of the D'Infreville duplex see Reid 1879, 590.

TALKING TELEGRAPH  Doc. 761

In testimony, Edison described the drawing at the top of the following document as

a transmitter consisting of a tube with a diaphragm to the center, of which is fastened a number of strings. These radiate out some distance from the face of the diaphragm and are connected to contact springs in front of contact points.

The springs and points are all included in a closed circuit containing a battery and a telephone receiver; upon speaking into this tube the contact points were vibrated, and resistance was thrown in and out of the closed circuit at one or more points by the vibration of the springs produced by the voice acting upon the diaphragms and springs.

This instrument was tried; the results were not satisfactory. [TI 1:34–35 (TAEM 11:38)]

Edison had drawn a similar sketch a week earlier.1

The three lower sketches apparently involve acoustic transfer telegraphy. There is another, more detailed version of the second one (the reed), labeled “Acoustic Transfer,” in another notebook.2 Edison made several other acoustic transfer drawings on this date.3


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Technical Note:  
Telephony and Multiple Telegraphy

[Menlo Park,] July 12 1876

Talking Telgh

Edison

X (photographic transcript), NjWOE, TI 2, Edison's Exhibit "Talking Telegraph July 12, 1876." (TAEH 11:203). Text, date, and signature inverted on original.

1. See headnote above.
New York, July 1876

From Lemuel Serrell

Dear Sir

I have a notice this morning on the Autographic Printing1 stating that Edward Stewart of Fort Madison Iowa filed an application May 23, 1876 that is considered to interfere with it.

Your preliminary statement, giving in full the dates of the conception, drawing, experiments, and actual operative apparatus must be filed before 29th inst.3

Do not lose any time in sending me these particulars fully, so that we shall be in time—

Your failure to give particulars on your acoustic telegraph case has perhaps proved fatal. I am trying to get time for it. On this case you had better also get out your statement, so that I can have it for filing if I succeed in re-opening the case.4

Yours truly,

Lemuel W. Serrell


2. Edison’s application for autographic printing (U.S. Pat. 180,857), filed on 13 March 1876.
3. On 26 July Serrell notified Edison that “priority of invention has been decided in your favor on concession of Stewart” (TAEM 13:1037). The interference was dissolved on 3 August (Pat. App. 180,857).
4. On 7 June, Serrell had notified Edison that an acoustic telegraph patent application (Case 118, executed 9 May 1876 and filed 16 May) was in interference with applications of Elisha Gray and Alexander Graham Bell (DF [TAEM 13:1031]). Edison’s preliminary statement in that interference had been due on 1 July. Serrell succeeded in reopening the case, and after several rounds of amendments Edison received U.S. Patent 198,087 on 11 December 1877 (Pat. App. 198,087).

New York, July 17th 1876

From Josiah Reiff

Dear Edison.

Sir Wm Thomson is in town—I wrote him this am asking him to visit Menlo if at all possible. & if absolutely impossible you & I would call on him here. If I get word from him that he will go to Menlo, I will telegraph you hour of our arrival etc.1

He sails Wednesday for Europe, & I expect to make an arrangement with him as an associate.2 I find Varley has become a confirmed spiritualist & thereby seriously injured his influence.3 I go to the country with O4 this evening—

I did not receive a check from you today, but hope to do so
not later than tomorrow—We had occasion to retain a lawyer in Washington Saturday about Quadruplex [Robert] Russell loaned me the money if he gets more money he is now expecting thro an appropriation before Congress, our affairs may take on a different shape at once—The old gent will put it up if he has it—That's proof of his faith in our success.

JCR


1. Reiff wrote to Thomson in early July to arrange for this visit. Although Thomson had planned an excursion on the Hudson River with his wife for the 17th or 18th, he must have visited Menlo Park on the 18th, as he departed for England on the 19th. In Edison's twentieth-century reminiscences—in which he misremembered Thomson's visit as being in 1879—he recalled showing Thomson experimental arrangements for eight-circuit acoustic transfer telegraphy. Reiff to TAE, 7 July 1876, DF (TAEM 13:1162); Thomson to Henry Draper, 14 July 1876, HD; Doc. 803; Telegr. 12 (1876): 180; App. 1.B59, D340.

2. Nothing is known of such an arrangement.

3. British telegraph engineer Cromwell Varley was an expert in cable telegraphy and Thomson's business partner (along with another British electrical engineer, Fleming Jenkin) in a firm controlling key patents for submarine telegraphy (DNB, s.v. "Varley, Cromwell Fleetwood"; Smith and Wise 1989, 701f). Spiritualism, a religious movement founded on a belief in communication with the deceased (usually via a medium), claimed several adherents in British technical and scientific circles, among them Varley, whose wife had become a medium (Oppenheim 1985, 9, 474 n. 64; Podmore 1897, 12, 37).

4. Unidentified; not likely to be William Orton.

5. A suit against Western Union, George Prescott, the Commissioner of Patents, and the Secretary of the Interior, had been filed in the names of Edison and George Harrington on 11 May 1876 in the U.S. Supreme Court. It sought to stop Western Union from using the quadruplex technology and the government from granting the related patent applications jointly to Edison and Prescott (Quad. TLC.3, 5 [TAEM 10:909, 948]). On Wednesday, 12 July, a motion had been filed by Western Union to dismiss the case against them. Although John Latrobe of Baltimore drew up the initial bill of complaint in the case (see TAEB 2:491 n. 3), the lawyer referred to here was probably R. D. Mussey, who apparently did most of the later work in the case for the plaintiffs.

6. Unidentified.

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Some further experiments on the Etheric Force.¹

a a are hard rubber sheets = b b b are wooden trays = black walnut)—very dry = c c c etc are white glass bottles wiped dry ½ inch diameter 6 inches high with round stopped leaving but little bearing for the wood to rest against = under each bottle is a piece of hard rubber polished on both sides 2½ inches diameter. =

4 cells were used. 1½ size with new zines & just amalgamted = then 2 cells on one set of the trays & 2 on the other =

Technical Note: Etheric Force

Menlo Park July 24 1876

July–September 1876
The last row or bottom bottles of the battery stand stand on hard rubber slabs 3 by .6. polished & ½ inch thick=

The magnet was composed of 2 bradley spools of naked wires, each spool having [---] exactly 6 ohms resistances & were of the same diameter & length = Inserted in the coils was a horseshoe of brass—diameter of brass wire 3/4 length 3½ inches width between prongs=

![Diagram]

The prongs as they entered spools were covered with thick shellac over which was tissue paper = the magnet ends were conducted to the key & battery by office wire= parafined cover= attached to the centre of the horseshoe was a wire also of office wire leading to the dark box= this wire run to a staple driven in the ceiling thence to another staple down to the box= This box was the one used in previous experiments & consists entirely of hard rubber polished into the ends of which are two screws provided with hard rubber heads, these screws run in brass sleeves fixed in the head of the round rubber box on their end are the lead graphite pencil points pointed at the End=

Could get no spark at first ascertained that the graphite points did not meet properly = had them fixed, could not get a spark for attached a condenser to one pole of the battery thus=—

July--September 1876
We then after few minutes trial got several sparks— detached condenser set it down on floor 5 feet from the apparatus on one side = got several sparks = took it away altogether still got several sparks = all then for ½ hour could not get none = put condenser within 5 feet = got after long trial one spark = took condenser away but after ¾ of an hour failed to get a spark either with condenser on one side or away altogether shewing perhaps bad adjustment of the graphite points = in fact the Screws went too tight to get a fine adjustment = are now having screw eased = afterwards couldn’t get anything either with condenser or without put condenser at one side at pole of batty at other end of spool & at key— inserted key as follows.

![Diagram](image)

after 20 minutes careful adjustment got very brilliant spark but couldn’t get it afterwards = after trying for over an hour added 4 more carbon ½½ cells to battery making 8 altogether =

Replacement the spools with a G & Stock printer’s spools with iron cores, & placing key by side of it thus got plenty sparks b

July–September 1876
Zinc cylinder laying across cores; when key was connected thus got nothing after 5 minutes trial

used the zinc cylinder laying on cores of electromagnet = if We had the zinc thus—

For fear that this threw it out of balance fixed the zinc thus

So the whole arrangement was thus=

Replaced key, got nothing = put key back on side of magnet got it a few seconds, then replaced key in centre & got it beautiful every time it appears to want a different adjustment = had my body divided so that equal portions should be
on a side removed every object from vicinity of magnet that would give a greater amount of surface or metal on one side or the other—then I closed key by a glass rod 3 feet long still got brilliant spark—

So this experiment would seem to indicate that the so called polarity experiments of Huston & Thompson were incorrectly made—

In addition to this we replaced the 6 ohm spools thus

and got it first time. this apparently shows that it is in. Thompson & Huston error was in the adjustment of the points= placing the key on one side allowing of a greater length of wire in one side at the moment of break & giving a greater spark, which was only reduced in strength by putting the key in the middle=

We then put the zinc cylinder inside of inside of one of the spools got spark good= then put a cylinder in each spool the zinc cylinders connected together with Copper wire got it ok= we then replaced the first horseshoe brass pieces= = 2 am have just tried another experiment that apparently confirms Huston & .T & Nulifies our previous ones tonight by putting one prong of brass Horseshoe in one spool get spark put it in the other get spark but when both prongs were inserted in both spools it took a long time to obtain a spark showing either a reduction in intensity or else that something must have thrown one side slightly out of balance & Ts theory is correct Tried it with zinc cylinders connected together with copper wire & spools placed wide apart, by careful adjustment sometimes got a spark but when one cylinder only was used got it without any trouble adjusting

_July-September 1876_
So far I think that H & T are confirmed as perhaps one spool of of the G.&S was stronger than the other or the zinc cylinder did not touch this would destroy the balance if there is one & allow the sparks but yet it is possible according to T & H position of the key etc preponderance of mass of matter is everything this is the cause this I do not find to be the case— but further experiment will determine this; perhaps better insulation of the cylinders from the coils is desirable=

One experiment remains to be explained

The spark was just as easily obtained by laying the cylinder on top of both spools as when put in the hollow of one

Note.

Its almost impossible to close this key with giving a spark in closing shewing there is a rebound & break on closing=

put hard rubber bushings in magnet where upon inserting zinc cylinders in each we got the spark every time with every-thing Central obut it was at least a twice as weak as when only one cylinder in one spool = if the spools were laid flat on rubber sheet didn't get spark with both cylinders in perhaps on account bad adjustment of points.

put magnet [u]right again both cylinders in got the weak spark every time added a condenser between key &

July–September 1876

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spool ies tied the earth sheets to wire to increase surface of metal it did not augment increase spark as it should according to H. &. T.\(^\text{10}\)


1. The experiments Edison recorded here involve a detailed, critical examination of experiments and conclusions of the Philadelphia science teachers Edwin Houston and Elihu Thomson, who claimed to have proven that all of Edison's etheric force effects were due to instantaneously reversed induced electric currents. They had disparaged his work in print, leading Edison in February 1876 to challenge his critics in Scientific American to "back up their assertions by experiment, and give me an equal chance as a critic" (Doc. 726). Thomson and Houston's subsequent experimental report to the Franklin Institute was reprinted in May in the Scientific American Supplement (1 [1876]: 326). In June that journal also briefly reported the critical presentation by Silvanus Thompson to the Physical Society of London ("Etheric Force," p. 405). For Edison's original experiments on etheric force, see TAEB 2, chaps. 10–11.

2. Thomson and Houston had emphasized the need for extremely thorough electrical insulation and physical isolation of the experimental apparatus.

3. Leverett Bradley was known for his patented magnetic helices and electrical measuring devices. See TAEB 1:141.

4. The circuit and physical layout, particularly the electrical and material bilateral symmetry down to such details as the orientation of the key, were designed to correspond to the experiments of Thomson and Houston; the two sides of their arrangement had been designed to produce mutually canceling effects, thereby demonstrating electrical polarity in supposedly non-polar etheric force phenomena and confirming their claim that only induction was involved.

5. Edison called this box the etheroscope. See Doc. 670.

6. Thomson and Houston contended that any appreciable disturbance of the symmetry of this arrangement, from the touch of a finger on one side to the mere approach of something metal, would immediately result in the production of characteristic sparks in the etheroscope.


8. Although Thomson was apparently the primary experimenter, Houston was the senior figure and his name came first in the published report. Carlson 1991, 60–62.

9. Edison probably meant "without."

10. Beyond the etheroscope designs in Doc. 766, there are further etheric force experiments in a notebook entry of 5 November 1876 using apparatus that is a modification of that shown here (Cat. 1172:70, Lab. [TAEM 3:314]); see also Doc. 840.
Technical Note: Multiple Telegraphy and Telephony

It is probable that when we get the transfer telegraph with several splits working that we can use one of the splits to work the local thus dispensing with the Controlling line=

Tried this last night and it worked well on wire between Menlo Pk and Albany & return with only 40 cells small carbon to transmit on
Same at other end

On closing the key the ground is disconnected and the battery connected this rushes over line to the distant station (which in practice will if receiving have its condenser cut out in the particular split receiving) and this waves continue only until the Condenser is charged which takes place with tremendous rapidity this short wave which is perhaps only a tenth length of a single vibration of the local forks proceeds over the wire & scarcely charges it but is sufficient to throw the tongue of the polarized relay to one side. When the battery is disconnected & the split put to earth the condenser which is now fully charged—discharges through the line in an opposite direction to the wave which passed into it & over the line & ths serves to throw the tongue of the polarized relay over to the other side. The great advantage of using these short waves & a polarized relay consists in using a very weak current which said polarized relays readily respond to and also a very short wave of current of the 2 polarities which are all that is supplied required to make dots & dashes; hence the wire is not charged anywise equal to what it is when permanent batteries are used at both ends and the effect of the escape is entirely prevented in this case by receiving on a ground. When the
wire is thrown on one set of instruments the wave is transmitted and then the wire before it is thrown on another set is put to earth simultaneously at both ends so as to discharge it of as far as possible the static charge of the line caused by the passage of this signallng wave & thus prevent it from rushing to earth through the next set of instruments on which the line is thrown instead of the condenser we tried using the induced current from an electromagnet. Thus

\[ \text{Diagram of circuit} \]

found that S must be of considerable resistance & that T should be quite long so as to lengthen the wave as it is exceedingly short & hardly sufficient to throw the polarized relay over to the other end. by nursing etc perhaps this would work satisfactory it has one advantage that if way stations are used local batters will be all that is required to work the induction magnet thus dispensing with main battery= We also tried in place of S. & T a differential magnet one set of wires in line the other in local with key this was not so powerful but could be made so--

There is a different plan for transfer which we tried and which appears to work very well which is the cutting in and out of the main circuit two receiving instruments simultaneously at both ends of the circuit at the same time and then doing the same one after the other of several instruments. We found that it worked perhaps more satisfactory with common

*July-September 1876*
instruments that by the transfer of the wire from one set of instruments to the other probably on account of the short circuit which closes on each instrument immediately after being thrown in the line acting as a shunt to allow of the circulation of the self induced current of the magnet itself which has a tendency to make the magnetism of the cores more continuous. The drawing is shewn on the next page; there is a difficulty with this which is the difficulty of discharging the wire after or between each transfer we tried innumerable devices such as condensers magnets secondary batteries arranged in various ways with the instruments & contact devices to compensate for the static charge of the line but with small success = Drawing shews one end. (Conceived about month ago)

There is another way which we did not try thus—

B short cfts 2 when on one side & 2 when on the other side A short cfts 1 on one side 1 on other

In place of reverse induction currents of short duration, inverted battery currents could be used and special mechanical device used so that upon closing the key, it or a sounder operated by local & key could be made to connect the battery p to line for an instant & then ground Then upon opening the key the ground could be removed and aZ pole of the battery connected to the line for an instant followed by dead
earth the idea is illustrated as below; of course there are many ways of doing this which any skilled person in the business could accomplish.

When key opens lever of sounder rests on a puts split to Earth in passing downward rubs on face of c inserted in ivory or other insulating substance = That sends copper current of short duration over wire. When lever of sounder
touches b & grounds split again = When lever rises platinum cylinder on end of spring g passes on the metal d & connects Z pole of battery to line for instant when it rises over top of d when lever touches a & grounds again. It may be necessary to shunt the polarized relays with either a condenser or a secondary battery so as to hold the lever or tongue to either side while no current is being received over wire thus preventing Extraneous currents from Effecting the relays = or perhaps by the use of reverse batteries a strong wave could be sent to throw the lever over immy followed by a weak continuous wave to hold it & so on always keeping weak current on line to hold lever on one or the other sides.

Last week we tried numerous experiments with a speaking acoustic telegraph whereby the human voice could be transmitted over a wire & which I have neglected to record =

brass diaphragm also used parchment, sending pHad a projection from middle of diaphragm to a contact screw by speaking in tube diaphragm set in motion & breaks transmitted to receiver set the magnet acting on armature secured to diaphragm set it in motion. Speaking was inferior but the singing was very clear & nice.

Tried tubes of various diameters & lengths diaphragms of various thicknesses also.

same Receiver In end of box placed several diaphragms of different diameters each of which had a contact point the
points serving to cut in & out of the circuit resistors but none breaking the continuity of the circuit. This owing to bad construction of apparatus appeared to be a failure yet I think if properly made it would be a success. Also tried a single diaphragm.

With platinum point dipping in a electrolytic Solution the vibration of the diaphragm serving to transmit waves to the receiver by increasing and decreasing the resistance of the circuit. This appeared to give best results.

Tried vibrating thread over which were contact levers cutting in & out resistance. Experiment was tried in very bad way & got no results but think there is something in it. This may work.

I think the high notes are made by the middle of diaphragm only vibrating while as the notes are lower more of the diaphragm vibrates. hence by placing contact points from cen-
tre to rim may get different rates & have levers cut in & out resistance

Good night 1 am—

T A Edison

James Adams

Chas Batchelor


1. Figure labels are "condenser," "slow fork," "Local forks," and "higher fork ie the multiple=" Another sketch of this arrangement appears in NS-76-002 (Lab. [TAEM 7:360]). Edison also drew a variant acoustic transfer transmitter on this date (NS-76-002, Lab. [TAEM 7:353]).

2. Figure labels are "forks," "T," "S," and "Earth."

3. That is, Morse instruments.

4. Figure labels are "Low," "higher multiple," and "no g[oo]d."

5. Figure labels on the first sketch are "forks," "same," "same," "same," "P," "Z," "metal," and "Earth," and on the second are "forks," "a," "b," "d," "c," "z," and "c."


7. The polarized relay appears at upper right in the drawing.

8. Figure labels are "Tube," "sender," and "Receiver."


11. Figure label is "cup of chemical solution."


13. Figure label is "speak here."

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Technical Note: Miscellaneous

[Menlo Park,] July 27, 1876

Acoustic annunciator for stable private house etc.

Use tin tube covered with a diaphragm & use silk thread as conductor of the vibrations, turn corners by use of wheels and also diaphragm. Have tried large number of experiments with this system =

---
Also

Tried this 2 weeks ago works fairly
A Repeater

Can be several transfer forks put in along wire; this circumvents the law of the Squares.

Conceived about 3 weeks ago—
Perhaps the following would work upon a line with great static capacity as the reeds would only respond to their particular rate & independent of all extraneous currents out of time with it no matter if very strong
in each split at both ends are reed transmitters & receivers arranged in such a manner that you can send or receive the rates of vibration being very much greater on lowest Reed than the transfer or Switch forks=

found that it was no go= With keys open any particular one would work OK but when you closed say 3 & worked 2 & adjusted right 2 would work OK but when 3 was opened it would change adjustment of 2 materially=

July–September 1876
It seems probably that a system of compensation could be obtained by using artificial line & extra splits using also differential relays thus

Same at other End
Acoustic transfer Roman Letter chemical printing telegraph=

local operated by Controlling line.
I propose to make an Ethericscope thus^10
1. Doorbells, call bells, and the like were essentially short-distance telegraphs (although many long-distance telegraph systems required such signals to gain an operator's attention), and were used widely in the second half of the century. It was also common to consider electrical systems together with mechanical means of communication, such as pneumatic tubes. Shaffner 1859, 346-53; Prescott 1879, 375-99; idem 1877, 883-92; Tunzelmann 1900, 282-84.

2. Figure labels are “spk,” twice in the first drawing, once in the second.

3. A repeater used a receiving device to operate an independent transmitting circuit that had its own battery, thus forwarding a strengthened signal to the next station (see TAEB 1:39-31). This New York-Chicago telegraph circuit shows a repeater at Buffalo (“Bu”) using a “Local Self mk & bk fork,” with condensers at both ends and at the repeater electrically isolating the line, as was common in cable telegraph practice. The “law of the Squares” Edison hoped to circumvent was William Thomson's 1854 analysis of signal speed on telegraph cables, showing that transmission time increased as the square of the length of the line (Smith and Wise 1989, 446-58, 660-67). Edison hoped that dividing a long route into segments would increase signal speed if the repeaters between segments worked fast enough. See also Doc. 769.

4. This paragraph and the following drawing are on a page archivally separated from the rest of this document. They appear to fit into these notes either here or below after “Same at other End.” See headnote, p. 19.

5. An artificial line used resistors and condensers to balance the electrical properties of a telegraph line. See TAEB 1:550 n. 2.

7. Figure labels are "R" and "Condenser."

8. Figure labels are "Line," "N," "P," "N," and "P."


10. The figure label is "mirror." It is not clear what is being measured by these "etheriscopes."

11. In this design the armature's vibration is provided by the motor of an electric pen (in its stand at left). The figure labels are "pen engine," "Thread," "sp[ri]ng," "mirror inside," and "Scale."

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Technical Note:

Acoustic Speaking Telgh

[Menlo Park,] July 27 — 1876

Technical Note:

Telephony

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Edison James Adams

X (photographic transcript), NjWOE, TI 2, Edison's Exhibit 73-10 (TAEM 11:217). *Obscured overwritten letters.

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July—September 1876
The operator spoke into the trapezoidal chamber from the right. Diaphragms at the left end of the tubes made intermittent contact with platinum points, shorting out resistance coils connected in parallel with each tube. The resistor/tube combinations were connected in series (cf. the multidiaphragm transmitter in Doc. 765). In testimony, Edison stated that this instrument did not work well but "you could tell that someone was talking and if you knew what they were saying it sounded awful like what they were saying" (TI 1:35-36 [TAEM 11:38-39]). Another drawing of this instrument is in Vol. 10:69, Lab. (TAEM 3:873).

Acoustic Transfer

Experiments with a chemical recording instrument at the receiving end with the 4 splits connected to the four iron recording points drum to ground at other end 60 cell small battery Relays in splits, Phila wire, weather moist Kennedy reports wires little soggy = Samples marked —A. result of wkg i key at time making long dashes; = Noticed that No. 3

Exhibits B. are the record with the ground wire inserted in the low forks the supposition being that immediately after the line has been taken from i set instruments & before it is put on another the idea being that putting wire to dead earth would free it of the return charge

Exhibit C. is the wire on short ckt the ground wire having been inserted on the multiple forks at both ends thus
Exhibit D shews same with Phila on= These shew where the mysterious bug was: the device for “Earthing” the wire on the low forks was a failure while that on the multiple is a success= Now this explains why all my rinkles failed.

Exhibit E will shew that the effect of the return charge so ascertain if the ground wire is sufficient to discharge it & prevent its entry into the signalling splits= The end sending Exhibits A. B. C. & D is now to Earth with keys closed= Nos. 4. 1 & 2 splits are to pens at recg station end while 3 is connected to key & batty 36 cells Callaud. 6 our next exhibit will shew the return chg from 60 small carbon— 7

Result: No return charge from 3 on [altern?] 8 36 cells Callaud= Now for 60 carbon small & 36 Callaud combined= This will be exhibit F

F. as carbon was to line return charge was zinc to pens hence Exhibits F are delusiv as marks came underneath paper

We reversed battery to make it correct and get exhibit G when the loop to Phila got foul of another wire with battery on & stopped us.

going to get RR station on our short to get N.Y. so we can have it fixed= 12 Midnight

Phila wire having busted we now make an artificial line composed of 5 resistance Boxes 9 Phelps' Duplex patent. 8 with .5. Duplex Phelps' Condensers Thus 9

\[
\text{Total } R. \ 3000 \text{ ohms } 4 \text{ sheets}^{10} \text{ in each condenser.}
\]

We now resume the test of the return charge from 60 cells small carbon & 36 Callaud together.—

Exhibit .G. 6

Exhibit H shews same condensing power but with—7,000 ohms R.R. 11

July–September 1876 91
Exhibit I shews 12 sheets in each condenser—nothing think' can just detect a little return charge

Exhibit J shews with same resist but with 28 sheets on each condenser—detection of return charge myth—

Exhibit K shews same resistance but 72 sheets condenser in each. It seems evident something is wrong—We reverse battery—Exhibit No—the ground wire being taken off we get Exhibit L, which shews return charge=we have copper to line—L shews on .2 best 4 next best then .1.4

We have in Exhibit M. the return charge with fork ground wires disconnected at both ends=72 sheets condine each condenser & 7000 ohms resistance.

Exhibit N same with ground on fork at distant end=

O. shews with both grounds on

We now reverse battery, zinc to line P. Shews get nothing—

I do not understand why we send out a carbon current & get back [-]a carbon current.

Pens are arranged thus12

Perhaps the forks are little out unison and it is leakage back through contact points.

Return Chg—

Exhibit P shews ground wire off at recg station on at diff distant station with splits to Earth, also with both fork grounds off also with all splits & fork ground off at distant=7000 ohms in 5 resistance Coils=74 sheet condenser on each of 5 condensers it also shews with distant entirely open with ground here=

_July–September 1876_
Exhibit Q shews distant end open splits ground & all at this end our main carbon to line, in our ground we have a reverse battery, zinc to line with 15 cells—kills return completely.

R¹ shews 5 cells on neutralizing battery
R² " 10 " "
R³ " 15 "

added 84 sheets to the 5 condensers  S¹ shews 5 cells on neutralizing battery
Now, 15 000 ohms 91 sheets C on each of 5 condensers

T.¹ 5 cells on neutralizing battery
T² 10 " "
T.³ 15 wiped out=

New experiment.
7000 ohms, 91 sheets each of the 5 condrs Key closed putting 60 carb & 36 Cal to line 15 cells opposite in gfork ground
Exhibit VU¹—key closed, other end all open.—'no exhibit nothing= working key—no exhibit,  Nothing=
Other end closed, our battery to line nothing.— making dashes, nothing.=
=Found that by putting back instruments for signalling that with 91 sheets condensers the rush in charge when acting like an escape and although we could only just get dashes the correctness of the infererance drawn from the above experiments cannot be doubted that is that the insertion of a wire in the multiple forks at both ends to discharge the wire after each wave is a big success & gives me the required compensation & which can be made as powerful as desired by the insertion of a neutralizing & opposite pole batteries in these ground wires. If we receive on a ground undoubtedly the signals will be perfect on very long esp lines, & I am certain they will be if way statins are used whose multiple forks have also a ground= = with batters at both ends we find that we havnt near the margin but I think there will be no difficulty in wkg from WNY to Washington direct with the z ground in the multiple fork.— We close our laborous night at 5 30. AM

T. A. Edison

A & Gil¹³ on—

July–September 1876
1. As indicated in the document, these experiments began on 27 July and continued until 5:30 the next morning.

2. The lines are numbered top to bottom: 3, 4, 1, 2.

3. Unidentified.

4. The sample tapes made during these experiments have not been found.

5. Figure labels are "Low forks," "Line," and "Earth = ."

6. Developed by A. Callaud of France, the Callaud battery was a simplified version of a Daniell gravity battery (see TAEB 1:615 n. 3). King 1962, 243, 245; Pope 1872, 106–7.

7. On the carbon (Bunsen) battery, so called because its anode was a carbon rod, see TAEB 1:599 n. 3.

8. Phelps had no patents for duplex telegraphy or for resistance boxes.

9. Figure labels are "to forks," "300," "300," and "to forks."

10. Condensers were constructed of interleaved sheets of conducting and insulating materials. By attaching circuit wires to different terminals on a condenser's casing, more or fewer of the sheets could be charged.

11. Figure labels are "1450" twice.

12. Figure label is "carbon."


Acoustic Transfer

Multiple Telegraphy

[Menlo Park,] July 28 1876

Technical Note: to control this is a multiple of the highest transfer fork

July–September 1876 94
The way station fork serves to discharge wire in midle and thus circumnavigate the law of the squares; I think it probablye that the line could be put to earth after each wave simultaneous at several stations.

T A Edison


1. Figure labels are "NY," "N Brunswick," and "Phila."
2. This text refers to the wires descending at the center of the sketch.
3. See Doc. 766.
4. Edison drew such an arrangement the following day. Vol. 10:87, Lab. (TAEM 3:889).

---770---

[Menlo Park,] July 29 1876

Technical Note: Telephony and Galvanometer

X water Idea being to speak in beaker & set the water vibrating this giving large amplitude in small side tube & thus increase & decrease the resistance giving the proper waves to magnet so as to carry on a conversation=

Instead of employing a lens Lens mirror on the needle of a Thomson. mirror galvanometer I propose to employ a think mirror about ½ inch long & ½ inch wide or even Smaller=

T A Edison

X (photographic transcript), NJWOE, TI 2, Edison's Exhibit 71-10 (TAEM 11:216). Obscured overwritten letters.

July-September 1876 95
I have an idea that each particular combination of elements & exciting fluids in a galvanic battery give out electricity with different rates of vibration¹ in the same manner as the vapors of metals in a flame are proved by the prism to have different rates of vibration¹ hence I have conceived the idea that with a cell filled with certain chemical solutions & platina electrodes that 100 units of current from one source will pass through that solution in greater quantity that 100 units from a different source; in the same manner that the heat from Hydrogen will pass through a solution of Iodine in Carbon Bisulph than from a candle or even from another source of light & heat of greater intensity= If the rate of vibration of the electricity is the same as the vibrating molecular time of the liquid through which it passes every little current will pass but if different it will pass readily. Hence I conceive that the Static Current³ passing out of a Submarine Cable has a different rate of vibration than that due to the primary battery current hence I propose to filter the primary & pre from the Static or secondary current by a Liquid whose time of vibration is the same or a multiple thereof of the static charge's Should I be unsuccessful in obtaining this I can employ another liquid and two signalling both of which produce the same charge in the cable but whose vibrating time is different and I insert a certain liquid that will allow the current from one battery to pass through regularly easily while the other does not pass so readily—hence the Cable³ will be constantly charged & Rapid signalling will be obtained.= I try a preliminary experiment this evening¹

T. A. Edison

¹. There existed at this time no generally accepted theory of battery action. Compare Edison's earlier idea on the wavelike nature of galvanic electricity (TAEB 2:159 n. 2).
². Spectroscopy—the study (usually with a prism) of the characteristic frequencies of light emitted or absorbed by particular sub-
stances—was a significant part of late nineteenth-century physical science. Edison had acquired a spectroscope in early 1875, experimented with spectroscopy as part of a telegraph system, and had considered manufacturing a toy model. See Docs. 428, 544, and 989.

3. That is, the discharge following each dot or dash, caused by self-induction and capacitance. It lengthened each signal on the cable, slowing down communication. It was a problem Edison had also encountered in automatic and long-distance telegraphy. See, e.g., Docs. 299 and 317.

4. After testing this idea experimentally for several days, Edison concluded that “It is evident that the phenomena so far recorded is nothing more than a destruction of balance & electromotive force of batteries—nothing apparently in it.” Vol. 8:288–304, Lab. (TAEM 3:716–32).

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Experiments in Electric Talking Telegraphs.²

Up to the present date we have tried a great many plans, a few of which are described below:

In our first experiments we found the parchment diaphragm in the transmitter could not be kept in adjustment owing to the expansion and contraction from moisture of the breath—a thin brass diaphragm was substituted which entirely overcame this difficulty but otherwise gave no better results—a brass diaphragm in the receiving instrument is inferior to parchment owing to a metallic ringing sound it gave.

Tubes of various sizes ranging from 3½ inches to 1¼ have been tried but our best results were obtained with a two inch diaphragm brass in transmitter parchment receiver with 3 ohm spool 2 cups of carbon short circuit shunting the sender with about 40 ohms—singing in any key can be transmitted accurately. Solid and spring contacts have been tried small platinum points and large brass discs, also discs & knife blade contacts with no gain.³
An arrangement of one box with 5 diaphragms of different size ranging from 4 in to 1 inch, no advantage.

A box with 3–2 inch diaphragms was tried each working independent & connected so as to throw in and out resistance various other changes were made in the connections.

Induction, static discharge, primary & secondary currents, on all the above & on nearly all of the connections singing could be transmitted perfectly—also playing on the cornet can be transmitted perfect—a plan which for want of perfect apparatus was not thoroughly tested is constructed on a very satisfactory plan & will undoubtedly be a great improvement. A good model will be constructed a thorough test made at once.

A platinum wire is attached to the diaphragm & immersed in a solution or liquid resistance the strength of the wave is by this means varied according to the amplitude of the diaphragm. Various improvements & modifications of this plan are proposed such as shown for increasing amplitude diamond shaped immersing point of aluminum.

Another plan is to be place chemical paper between contact points & the variation in pressure of diaphragm gives corresponding variations. strength of wave. The sketch on the back of this sheet is a plan proposed by Edison & will be tried in due time. The introduction of saturated felting in place of chemical paper is also proposed.

Fig. 1

July–September 1876 98
The following plan will be tried at once represented in Fig. 1 on opposite page—diaphragms arranged to force out water against a counterbalancing diaphragm the talking diaphragm is placed in close proximity to metal plate leaving only small amount of solution to be vibrated the two counter-balancing diaphragms furnish elasticity.

X (photographic transcript of handwritten transcript), NjWOE, TI 2, Edison's Exhibit 101-10 (TAEM 11:218).

1. This transcription of Ezra Gilliland's memorandum (see note 2) was entered as an exhibit in the Telephone Interferences. It contains several discontinuities and awkward phrasings that appear to be artifacts of the transcription process.

2. In discussing this set of notes Edison testified that he set Ezra Gilliland to work "about May, 1876," with James Adams to assist him, and that they continued experiments to "about August" (TI 1:34 [TAEM 11:38]). However, both the general pattern and details of this research seem related to experiments undertaken during July. (cf. Docs. 759, 761, 765, 767, and 770). Alexander Graham Bell's attorneys later argued that the internal evidence of these notes suggested that they did not represent three months' experiments (Brief for Bell, TI 4 [TAEM 11:197]). Undated drawings that may be related to these notes are in Vol. 15 and NS-Undated-006; for example, see the item from Vol. 15 entered in TI 2 as Edison's Exhibit 79-15 (TAEM 11:617).

3. In his testimony Edison described the instrument shown in the drawing below as consisting of a "multiplicity of contacts, in connection with a vibrating spring, set in motion by a diaphragm," and said that it was "made and worked to a sufficient degree to allow us to hope." (TI 1:34 [TAEM 11:39]).

4. What may be a related set of experiments is in Doc. 765.

5. See Doc. 765 for related experiments. A possible example of the "diamond shaped immersing point" is in TI 2, Edison's Exhibit 79-15 (TAEM 11:617).
6. This is the end of a page; it is not certain that the remaining text immediately followed in the original.

7. Because this is a transcription, it is not clear whether this refers to a drawing copied onto these pages. The original is no longer extant.

8. See Doc. 759.

9. In his testimony Edison described this design as

a tube, with a diaphragm resting upon a flexible pipe joining two reservoirs of water. In each reservoir was an electrode, and the same were included in a circuit containing a battery and a telephonic receiver.

The resistance of the circuit was altered by a compression of the flexible tube altering the size of the column of water between the reservoirs.

Edison claimed that this instrument was made in August or September 1876 and that “it was said to work very good.” TI 1:36 (TAEM 11:39).

10. According to Edison’s testimony, the following design consists of a resonant tube, or a chamber provided with a diaphragm immediately opposite is a spring, secured at one end by a screw, and near the center to the diaphragm, and upon the end of the spring is a T, having notches, against which a number of contact springs faced or rested.

These springs were arranged with resistances, so that by the vibration of the springs connected to the diaphragm a complicated system of contacts were made, which put in and took from a circuit resistance, the circuit containing a battery and a telephonic receiver.

Edison noted that this instrument was constructed in September or October 1876 and that “it did not work satisfactorily.” TI 1:36 (TAEM 11:39).

Acoustic\textsuperscript{2} T[\textit{transfer}]\textsuperscript{a} Duplex[\textit{ed}]\textsuperscript{a} on one w[ire]\textsuperscript{a}

[\textit{Drawing on facing page}]

Adams\textsuperscript{4}

1. "Worked Bang up Sept 17 Sunday" was added below the drawing by Edison, that date was a Sunday in 1876, not 1875. Moreover, none of Edison's dated work on circuits of this type occurred in 1875. See Doc. 795.

2. On this date Edison also made a closely related drawing labeled "Acoustic Transfer Duplexed making 8 messages on one wire" and noted "Tried last night on Phila loop fair Success—" (Vol. 8:334, Lab. [TAEM 3:764]). For other work on acoustic transfer from early August see Vol. 10:88–108, Lab. (TAEM 3:890–908).

3. Figure labels are: "R," "Cond," "New York," "Line," "Boston," "R," "con," eight more "R's," and battery pole labels "z" and "e" twice.

4. Edison's signature was probably on the portion of the page now missing. He and Adams signed (and Edward Johnson witnessed) the other sketch of this type from this date (see note 2).

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Notebook Entry:
Electromotograph

[Menlo Park,] Aug 3rd 1876

July–September 1876 102
Electromotograph

July–September 1876
Delicate Electromotograph

Thos A Edison

James Adams

July–September 1876
1. These electromotographs appear to use a small mirror to indicate deflection caused by increased or decreased friction. The design may have been inspired by William Thomson's visit to Menlo Park in July, as Thomson's mirror galvanometer used a similar reflecting device (see TAEB 2:754 n. 1).

A small motor MM, comparable to the one Edison used in his earlier work (e.g., Docs. 165, 211, and 262), drives flywheel F through a worm gear. The flywheel in turn spins a disk inside casing D (visible in the next drawing). The electromotograph action (friction change) occurs where the end of shaft V rests on the spinning disk. The two horizontal arms A A mounted on the vertical shaft are held by springs S S (secured to D) to prevent the shaft's rotation. The presence or absence of a current through the disk and V alters the friction at the disk, which changes the torque on the vertical shaft and thus the displacement of arms A A from their resting position. The small mirror R is attached to the left horizontal arm and reflects a beam of light (dashed line) through tube T onto a scale (not shown). H is the frame of the instrument.

The previous drawings show other mechanical embodiments of this idea.

2. The next drawing shows two overlapping designs, not one device.

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Notebook Entry:
Electromotograph

Electromotograph Experiments

[Menlo Park,] Aug 4 1876

Standard 3000 ohm Pyrogallic paper same as made for Domestic platina pen=
Hydrogen—vibration just vi felt

July–September 1876
O. & H—BiSulphide Carbon Acetic Acid—nothing on 3000.

H. Alcohol & Caustic Soda, will work equal to pyrogallic through 30,000, ohms— the paper owing to evaporation of alcohol is quite dry in few minutes gets perfectly dry. it works quite strikingly through 70,000, ohms all we had—by opening & closing the key & stopping & starting the vibrations the effect is enormously detection is greatly conveinenced as the hand can readily detect the stopping & starting of the vibrations = Very plain through 70

We now take Caustic Potash Soda & Alcohol as a standard, vibrations when key is worked being clearly felt through 70,000 ohms

O & H Alcohol & Oxalic A. nothing felt at 70,000.

Silver & Cop on Ag—Alcohol & Tartaric acid vibrations just perceivable not so good as standard

O & H. Nut Oil Sweet Almonds & Iodine nothing surely felt

O & H Oil Turpentine & Creosote—nothing felt

O & H Oil Rosemary Conc—nothing surely felt—

O & H. Spirits Turpentine & Glacial Acetic Acid nothing felt yet when key open apparently felt some vibs it may be that this sol is of extreme delcy & requires perfect insl insulation to stop vibs=

O & H Bisulphide Carbon Glacial Acetic. A. nothing felt sure=

BiSulph Carbon—Creosote nothing dries almost instantly=

Spirits Turpentine & Iodine nothing felt=

BiSulph Carbon—Spirits Turp= nothing

Spirits Turpentine Hyposalphite Soda nothing

Spirits Turpentine Carbozotic Acid— nothing

By putting vibrating apparatus away from hand EMG so as couldnt feel mechanical vibs—could tell better;

Alcohol & Fused Chl Zinc. just feel on Hi=*

T A Edison


1. Figure labels are (clockwise from top) “Electric pen,” “sounder Repeater,” “2 cells,” “6 cells,” “Rheostat,” and “closed.” See TAEB 2:540 for an illustration of the hand electromotograph.

2. That is, with the electromotograph contact attached to the cath-

July–September 1876 106
ode (the battery pole that will evolve hydrogen gas from an electrolyte). Similarly, "O" in this document refers to the anode.

3. Carbazotic (picric) acid.

4. At this point there follows the notation "8:20 PM we start again" followed by several more pages of similar experiments (TAEM 3:695-703).


Tonight tested our own mirror gal found that it was hard to keep it at a zero. = with 1 Daniell or rather Callaud found that it was extremely delicate unexpectedly so, if there are no sources of error¹

Got deflection of 12 degrees with wires twisted as shewn.

Then brought up The Elliot Thomson & had lot of trouble to get it to zero & at last broke the fibre in the endeavor hence couldn't compare =

I think the Elliot mirror is too clumsy =

X, NJWOE, Lab., Vol. 8:278 (TAEM 3:705).

1. Figure label is “insulated.”
2. The Thomson mirror galvanometer from Elliott Bros.

[Menlo Park,] Aug 7 1876—

Electromotograph

We have just got our new paper wetter finished it works tolerably well.

Have wet some pyrogallic paper Ferricyanide of Potassium ditto & Some of the Electromotograph paper of Acetate of mercury & Caustic Potash =

We are going to attempt repeating through the Phila Loop:¹ connecting in the manner shewn in the diagram²
Perhaps we shall have to shunt the E.M.G with a magnet, also to use a plain resistance shunt at Transmitting end even perhaps insert a magnet in the said shunt =

We have made a slight alteration in the method of putting on the springs on the lever of the E.M.G. in all previous Experiments we have put springs near to fulcrum thereby increasing the friction in its pivots. we have now put the springs nearly nearer the extremity of the lever reducing the friction in pivots & making a much better adjustment =

I think that the lever should be arranged thus
The point wants to be near edge of lever so there shall be now twist = The lever should also be made with ribs = Thus

T A Edison


1. Edison had tried for years to devise a repeater that was fast enough and sensitive enough for the automatic telegraph system (see, e.g., Doc. 105 and TAEB 2:284 n. 3, 662 n. 8). He had hoped for some time that an electromotograph instrument would solve the problem (see, e.g., TAEB 2:284 n. 4). Later that night and the next day they repeated at 200 words per minute through the Philadelphia loop using a 600 ohm shunt magnet at the transmitting end and 90 cells Callaud battery. (A sample tape from those experiments, supposedly placed in a scrapbook, has not been found.) Vol. 8:309-10, Lab. (TAEM 3:737-38).

2. Figure labels are “Ferrid auto Receiver,” “Local circuit,” “Menlo,” “65 miles Phila 65 miles,” “Menlo,” “auto perf paper,” “Menlo ground,” and “N York.”

3. Figure labels are “previous position of spng” and “position now.”

4. Before placing the electromotograph repeater in the Philadelphia loop, they discovered that the point was too sharp to allow the lever to move freely. They flattened the point to solve this problem. Vol. 8:309, Lab. (TAEM 3:737).

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Notebook Entry:

Electromotograph and Automatic Telegraphy

[Menlo Park,] August 9, 1876

Electromotograph

Last night we had the most successful of all experiments with the E.M.G= worked it through Phila Loop with 90 cells— first class without a false dot & perfect at 300 words per minute & it did not change its adjustment whether we went at 20 or 300 per minute also run to 800 per minute & got it good but occasionally there would be no breaks between a dash & dot = Shunted E.M.G with 1 spool of a WU 120 ohm relay & sending shunt 600 plain found that whole WU relay was not so good as ½ thus shunted the lever moved with great force at 300 so you could hear every dot but of course couldn't read=

These results were attained by the use of a very strong solution of acetate of mercury, reduced to metallic state by Caustic Potash = The solution made night before was all together too weak. We worked point up pretty close = I remark here

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that a successful E.M.G paper must have an initial Lubrication to prevent false vibrations & that is the reason why pyro—caustic soda—silicate soda & acetate Hg or metallic Hg gave best results, because these are themselves Lubricating materials. We also found that with the acetate solution & at 300 per minute we had considerable range of adjustment we used considerable pressure — afterward tried it on a loop to Albany & back 380 miles it worked very fairly at 100. per minute, though we had too small battery added 30 cells carbon making bat equal 150 cells Callaud= This didn't increase speed or improve it= we qu put WU relay in sending shunt didn't improve it much— varied shunt= it wa came 6 am when we quit= Are having lever stiffened for tonight — & are in meantime trying to wet paper with a Hg Sol & letting roll dry & rewetting with a reducing agent so as to reduce the Hg to metallic state on paper itself & not mechanically as previously—

T A Edison


2. A fast Morse operator could send or receive upwards of forty words per minute. Three hundred words per minute (roughly seventy-five signals per second) was far too fast to understand.


On 10 August, Edison, Adams, and Edward Johnson experimented further with the electromotograph repeater, receiving 200 words per minute on a Menlo Park–Boston loop of 600 miles (950 km) and receiving 125 words per minute on a Menlo-Philadelphia-Boston-Menlo circuit of 700 miles (1,100 km). Vol. 8:341–43, Lab. (TAEM 3:771–73).

London E.C. August 15, 1876

My dear Sir

The first consignment of Pens haves—I believe—arrived in Liverpool but I have not yet received them here,— probably I shall have them tomorrow.—

After a discussion with Mr. Breckon¹ we he decided to take offices at the above address and to carry on all business con-

From Frederic Ireland

July–September 1876
nected with the Pen from there—² please therefore address all
future Communications to me to New Broad Street, and send
Pens there at the rate of twenty per week unless I ask for con-
signment elsewhere either by letter or wire.¹

You have not yet sent the particulars of price of the various
parts of the pen.—⁴ please let me have these by return— I
think it may be useful to both of us.

The offer you made to Genl Lefferts has now expired—⁵
Will you be good enough to write Confirming the offer you
made to me for France Belgium &c—

As soon as I have organized the sale in England⁶ &c I will
take the Continent in hand—

Pray push the Pens forward as fast as possible— if you can
send an extra number please do so I am Yours faithfully
Frederic Ireland⁷

ALS, NjWOE, DF (TAEM 13:970).

1. Nothing is known of John Breckon beyond his involvement with
Edison’s electric pen in Great Britain. See Doc. 925.

2. On 21 August, John Breckon wrote to Edison, assuring Edison of
his good will and best efforts regarding the success of the pen in En-
gland. By 1 September he and Ireland were calling their business the
Electric Writing Co. Breckon to TAE, 21 Aug. 1876; Ireland to TAE,
15 Aug. and 1 Sept. 1876; all DF (TAEM 13:972, 969, 974).

3. At this time the pen business was being run by Charles Batchelor
out of the office at 41 Dey St., New York, and the pens and presses were
being manufactured by Gilliland & Co. in Menlo Park. Charles Batchel-
or’s testimony, TI 1:229 (TAEM 11:91); advertising circular “Centen-
nial Exhibition,” 76-007, DF (TAEM 13:962); insurance policy of 24
Apr. 1876, DF (TAEM 13:924).

4. A price list dated 3 October 1876 is in Lbk. 3:6 (TAEM 28:498).

5. The agreement (Doc. 746) had presumably expired with Lewis.⁶

6. In another, apparently earlier, letter of the same day, Ireland asked
Edison to confirm Ireland’s authority to sell the German patent rights.
DF (TAEM 13:969).

7. Nothing is known of Ireland beyond his acting as an agent for John
Breckon and Thomas Clare in the purchase of rights to Edison’s British
electric pen patent and his subsequent role as manager of the Electric
Writing Co. By October 1877 he had left Electric Writing for the City
Circular Co. Ireland to TAE, 29 Oct. 1877, DF (TAEM 14:420).

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Notebook Entry:
Electromotograph

Electro Motograph
Experimenting on different porous substances to replace Pa-
per in the E.M.G.—

Menlo Aug 17th 1876—

July–September 1876

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Found Black Lead\textsuperscript{1}—very absorbant—Lamp Blk Lead—Pyro Gallic—solution—Good results—but difficult to keep moist—admits too free passage of current—don’t give time for Decom. of Solution—Gets soft on surface—Powdered—& rubbed on metal gives better results.*

Chalk & Pyro Gallic—As good as Paper—good conductor at same time admits of motograph action. Holding solution well—chalk not being of itself a conductor—allows the solution to perform that function alone—

Licorice and Pyro Gallic—Licorice soft & rubbed on the Iron—when, nearly dry is quite good\textsuperscript{a}

Note It is evident the Electro-Moto action—is due entirely to the solution—It only requires a solid to hold it.\textsuperscript{a}

Cork—Pyro Gallic. Pyro-Gallic on surface gives conductivity—but no E.M.G. action\textsuperscript{a}

Gum Tragacanth—Pyro Gallic No result—except conductivity\textsuperscript{a}

Grape Sugar—Pyro Gallic—No good\textsuperscript{a}

Sal. Amoniac—Pyro Gallic No good\textsuperscript{a}

Soap Stone—Pyro Gallic Made into Paste—No good

Carbonate of Amonia—Pyro Gallic Works well with good Pressure—but dissolves quickly in the solution\textsuperscript{a}

Borax—Pyro Gallic—“Afraid it’s a Failure”\textsuperscript{a}

Camphor—Pyro Gallic—No icks\textsuperscript{a}

Note It continues to be apparent that surface conduction don’t give E.M.G. action—The action would seem to be direct through the substance\textsuperscript{a}

Plaster of Paris Pyro Gallic Thin Layer—mixed with Pyro Gallic Excellent Good Conductor—& Good. E.M.G. action

Pine Wood—Pyro Gallic very good—Will try again when more thoroughly wet.\textsuperscript{a}

Tried it again—about same\textsuperscript{a}

Chalk is Best so far\textsuperscript{a}

Edison

E. H. Johnson

X, NjWOE, Lab., Vol. 8:349 (TAEM 3:779). Written by Johnson. *Followed by centered horizontal line. \textsuperscript{a}Interlined above.

1. Black lead (also called plumbago or graphite), lampblack, and gas retort carbon were all forms of carbon. Although the names were sometimes interchanged casually, each designated a material with specific properties. Graphite, the lustrous, slippery form of carbon commonly used in pencils, was employed as well for stove polish and rustproofing. Lampblack was a very finely powdered, flat black form of carbon often used in inks. Both were in turn very different from the shaped carbon
used in batteries and arc lights, formed of gas retort carbon (which will
scratch glass) or manufactured from repeatedly baked mixtures of coke,
coal tar, or other crude carbon materials. Manufacture of the various
types was not standardized, however, and any sample might have prop-
erties different from another. For example, plumbago sold for house-
hold use was often a much poorer electrical conductor than plumbago
from scientific instrument suppliers, and commercial lampblack (also
called spirit black) left a white ash if burned, whereas pure lampblack
left no residue. Bloxam 1869, 97–98; Sprague 1875, 102–4, 278–79;
Gideon Moore to TAE, 25 July 1877, DF (TAEM 14:103).

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Notebook Entry:

Electromotograph

Electromotograph =

Have been making a large number of Compounds of plaster
of Paris HO₁ & other things such as Phosphate of Iron, Chalk,
Litherage² etc to ascertain which is the best substances to
make disks of for the mot E.M.G = We having ascertained
that the action is entirely due to the decomposition of the
fluid. These will not be dry until tomorrow = Had Wurth fix
the EMG from a three point tripod (which was a failure owing
to want of a proper substance to hold the solution) to a
disk, thus

![Diagram]

We put on a washer turned from natural chalk, which had
hardly been wet with pyrogallic³ when we found that the Mec-
nanical Vibrating action had ceased⁴ and that apparently one
of the main obstacles had been removed — by Remoistening
and increasing friction spring⁵ found that it Repeated at about
100 per min 5000 ohms 20 cells battery perfect⁶

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E.M.G.

With the new E.M.G. & chalk pyrogallic we receive hundreds of wds over loop to Phila at rate of 200 per minute every dot perfect not withstanding that the shafts run out. We are going to have the shafts all put in clockwork centre to get rid of shake.¹

X, NjWOE, Lab., Vol. 8:352 (TAEM 3:782). Document multiply dated. "with pyrogallic" interlined above. ¹Multiply underlined. ¹Interlined above. ¹Edison marked this sentence with an octothorp in the left margin. ¹Underlined twice. ¹Followed by centered horizontal line.

1. Water. Edison sometimes followed a common chemical notation and designated water in this way; other times he used H₂O.
2. Litharge, a fused lead monoxide.

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[Menlo Park,] Aug 20th 1876

Technical Note:
Printing Telegraph

Acoustic Printing Telegraph²
Caveat³

July–September 1876 115
Invented by
T A Edison
James Adams
Chas Batchelor
John Kruesi


1. Figure label is "15 teeth"; the letters "A . . . G" are on the wheel.
2. Additional sketches of this design are in NS-Undated-005, Lab. (TAEM 8:295–96, 298–99) and in Cat. 997:26, Lab. (TAEM 3:365).

Other sketches of Edison's acoustic printing telegraph idea.

3. Edison filed neither a caveat nor a patent application for an acoustic printing telegraph. However, on 30 October 1876 he executed a patent application (U.S. Pat. 200,032) for a synchronous movement for telegraph instruments based on this design and indicated that it could be used for "controlling the movements of type-wheels in printing-telegraphs at distant stations."

Edison's drawing, with instructions, of the model for his patent application for a synchronous movement for telegraphs.

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Introduction to Electromotograph Experiment Series

Notebook Entry:

Electro Motograph.

Experiments today—To obtain a solution which will show greatest difference in friction with the minimum of Polarization.

Note We have found (Aug 23) that passages of current through any substance containing strong solution of Caustic Soda—that great polarization is had. If the Decomp. points are constantly moved this Polarization is not noticeable & no inverted Current is discharged from the Electrodes. But if the current is allowed to remain closed—the point resting upon one spot—Enormous Polarization takes place—so great that a current from 25 Carbon Batty. is insufficient after 2 or 3 mins to work promptly an Ordinary Relay—but if the Point be moved to a new surface on the chalk the current passes with full strength, & the Relay works strong. Or if the point remains on same spot & the current be reversed—the same effect is had—but again rapidly weakens We have also found that this Polarization is not so great in some solutions as in others—for instance if we wet 4 strips with 4 different solutions respectively Ferrid Cyanide Pottassi. Pyro Gallic Acid—Caustic Soda—& Acetate Mercury & Caustic Pottash—they Polarizes very rapidly, except the last, which requires a long closure of the current—to eshow any Polarization. This explains the why the best results have heretofore been obtained by the Mercury Salt. And also why a shunt cannot be used with solutions which Polarize rapidly—the electrodes sending an Inverted Current thus disturbing their own adjustment, by circulating on the Shunt.

The above we consider a very important “Bug” discovery—although noticed many times previously—we were not forcibly impressed by it—because of the feebleness of the shewing—The caustic Soda however shewed the Bug so well defined as to compel his recognition—whereupon a great many heretofore unexplained Phenomena—becomes easy of explanation.

It is noticeable that Caustic Soda—is an element of Maximum Effects. In whatever direction used it appears to produce results more marked than other solutions.

With this New Element in mind—we now proceed to test for a non-Polarizing agent either to use Independently or to combine with Caustic Soda.
Ckt. 600 ohms. 25 cells Gold Carbon
Hand Motograph—WU Relay 140 ohm in ckt.
Hand Points—Round \( \frac{1}{16} \) in Diam (oval end) Plat \( \frac{1}{4} \) [In] Sqr Surface

In each case we use our 20 Gramme Sol. or next below in case No 20 on hand—


1. As in a battery, polarization caused by the migration of ions from the solution (acting as an electrolyte) to the points of the electromotograph (acting as electrodes) set up a counter electromotive force.
2. Over the next several days (24–26 and 30 August), the laboratory staff conducted 248 experiments using various solutions with metal points of aluminum, copper, lead, nickel, platinum, silver, tin, and zinc. They compared the resistance when the pens were stationary or moving, the polarization with current flowing in either direction, and the friction with current flowing in either direction. Experiment 248 for a "Caustic soda strip quite Dry" showed the best results and they concluded that "This Fills the Bill." Cat. 996:3–35, Lab. (TAEM 3:280–96).

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Notebook Entry:
Miscellaneous

Delicate Electromotograph

[Menlo Park,] Aug 28 1876.

rotated slowly by an Electric Engine.
Reverse Current EMG
EMG principle S is a scraper which cuts the chalk off even as it rises & thus gives the recording point & lever a clean fresh surface—

Scheme for Autographic Printing.
Write on a sheet of paper with strong solution of Bichromate of potash, then have dry gelatine covered sheets, slightly moisten these, then lay on Bichromatised writing sheet press. This will transfer writing to Gelatine then expose to light this will render parts where Bichromate writing is in-
soluble, then either wash & print by porosity of paper or by photolithographic style.

Ink Spirter Motograph

I find that if a glass tube be inserted in a bottle containing HS. gas and the point of the tube drawn out very fine that HS passes all right but by holding paper wet with a Solution of Plumbic Acetate front of the orifice that the mark so obtained is to broad it spread spreads 1/6 even with very narrow orifice. Tried holding little piece of Sulphuret of potash near lead paper but it dont give off enough gas; the peice was rather old.

Magnet

Constantly rotated =

placing the large permanent magnet where it is, is a mistake the working tongue X should be polarized so that both ends should have the same polarity. This arrangement is a partial application of the EMG principle to a polarized relay.

I have an idea that an artificial rose could be made of such an nature that it would remain stiff and at the same time absorb by capillary attraction atto of Rose perfume from a bulb which is filled with it & which acts as the holder in the button hole.
I have an idea that a cheap 25¢ pocket Spectroscope would sell on the street the tube being cast in lead or zinc, Canada Balsam used as a magnifier & common chandelier prisms broken in short pieces used for prisms.

I have an idea that the electric pen could be attached to a stiff brass pantagraph and very nice drawings made with it.

I have an idea that perforated stencil sheets similar to those produced by the electric pen only done by a stamping machine & with larger holes representing outline statuary, Landscapes etc could be sold in large quantities to Druggest etc to ornament mirrors windows etc by marking through the stencils with French Chalk; etc.

in addition books accompanied with Colors etc could be made whereby with a number of stencils any kind of a picture, could be produced, & these books sold to the trade to be used for educational purposes & for amusement. Spoke of this over 8 mos ago.

Battery.

I used coke which is a fair conductor & very porous and string the pieces on a copper wire so that the whole is electrically connected together and mixed in with the pieces are the crystals of Cupric Sulphate= the Coke soon becomes plated with copper & owing to it porosity gives an enormous surface I propose another method thus:

I use a porous tube open at both ends in which I place the zinc hence I am enabled to place the coke from bottom to top and near the zinc.

Another method is to place a disk of Copper at the bottom and fill in granulated tin copper or lead.
Powerful inexpensive condensers.

\[ \text{c & b are platinized disks, a is a block of chalk or other porous substance saturated with polarizable chemical such as Caustic Soda. (Strong.)} \]

\[ \text{1st Acoustic Telegraph}^9 \text{ I propose to use a number of tuning forks upon the ends of which are lever resting up revolving chalk cylinders moistened with a chemical solution, and so arranged that the Em.g. principle sets the fork in motion, one single cylinder may be used to set several forks in motion.} \]

T. A. Edison

Chas Batchelor

James Adams


1. In this electromotograph design, rotating tub \(T\) contains a liquid into which electrodes \(E\) and \(E'\) project. Magnet \(MM'\), with its poles opposite to those of bar magnet \(B\) (with poles \(N\) and \(S\)), holds \(B\) in place against the rotation of the liquid. Apparently the electromotograph action—a change in friction—is to occur at the surface of the electrodes as the liquid flows around them, changing the torque on \(B\) and causing point \(C\) to move between the contact points. The line current would pass through the liquid and into the electrodes, but it is not clear whether the current would then pass into bar magnet \(B\) and through the pivot arm \(P\), or be taken off the electrodes directly by wires. The local circuit, which would pass through contact point \(C\), is not shown either.

2. This is the electromotograph equivalent of a polarized relay, in that it is quite sensitive and responds to reversing currents. Here the current flows through wire \(W\) and point \(P\),
An electric pen connected to its power source by a spiral spring.

3. Figure labels are "chalk" and "Electric Eng."

4. Figure labels are magnet pole designations and "ink," "weight," "platinum point," "chalk," and "Electric Engine." A drawing of 12 September 1876 shows this device in a circuit. Cat. 997:22, Lab. (TAEM 3:363).

5. Figure labels are "X," "S," "N," "iron," and "Electric Engine."

6. Attar of rose, a fragrant essential oil made from rose petals.

7. On 10 September, Edison proposed using a pantograph in combination with an electric pen for perforating messages for an autographic telegraph (Cat. 997:21, Lab. [TAEM 3:362]; see also Doc. 934). On 29 August he also proposed two alternative methods for operating the pen; one used a flexible spiral spring and the other incorporated an air engine (Cat. 997:9-10, Lab. [TAEM 3:356-57]).

8. Figure label is "Zinc."

9. Figure labels above are "chalk," "Emg," and "Electric Engine."

Notebook Entry: Relays

The idea has occurred to me that the EMG principle of wkg by a difference in friction might be applied to an electromagnet. I took a magnet extended one core by placing an armature upon it & by opening & closing the key & passing along a flattened iron wire, the thumb produced by the friction caused by magnetization and the normal friction the was apparent. I propose to embody this principle in a machine thus.
Of course there is arrangement doesn't work by isn't exactly like the principle of the EMG working by difference of friction, its the principle of increasing delicacy of magnetic relays by working in actual contact, when the end of the iron core has a ring of ivory of considerable thickness to prevent the effect of residual magnetism it will be noticed that the power with which a relay lever moves is always the same; no addition over a certain amount can change the adjustment. In fact this principle opens a new field in magnetic telegraphy and in electromechanics.

Actual Contact Magnet Relay EM.G. Magnet
New York, Sept. 4 187[6]*

Friend Edison,

You don't seem to get up here "much" lately.

Mr. O.¹ says that he has set so many times in his own mind to go down to see you and failed to be able when the time came that he will not try to say "when" again but start if any time he is able—

Meantime he thinks for your good some one should make you a visit. He understands why you do not want certain persons to do so, and I know fully appreciates your reasons.²

But he suggests that as you are on Sup' Van Horn's³ wire that you give him (Van) a written invitation to come down.

He will take it to Mr O. of course, and will get his instructions, which⁴ will be to "go and see and say nothing to any one but the man he goes for." You will like Vans quiet observing way and you can trust him surely. He knows but one man in New York.

Batch has got a good office here and every thing in it that the heart of man can desire except a decent pen. Yours

N. C. Miller.

P.S. V. was away all last week, just home now send up to him early as O. says Gray is crowding things, and is now here.⁴ M


¹. William Orton.
². See Doc. 732.
³. John Van Horn (b. 1827) was general superintendent of Western Union's southern division. He entered telegraphy in 1850 as an opera-

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tor and during the Civil War was president of the Southwestern Telegraph Co. In 1878 he was elected Western Union vice president in charge of the electrical department, statistics, and contracts. Reid 1886, 668–69.

4. A 23 September Telegrapher article indicated that Elisha Gray had been at the Western Union office in New York for several weeks demonstrating his electro-harmonic telegraphic system for sending four messages each way on a single wire. The article described a successful test between New York and Philadelphia on 21 September. “The Electro-Harmonic Telegraph System,” Telegr. 12 (1876): 232.

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Notebook Entry: 
Electromotograph

[Menlo Park,] Sept 4th 1876.

Electro Motograph Continued—

Pending the construction of an Instrument designed to present a new surface to the friction point so as to avoid the effects of Polarization—the tests found on the preceding Pages were made having in view the attainment of the same object in a different way—i.e.—by finding a solution having great frictional Difference with a minimum of Polarization.

Of the Results of the latter, record will follow—

Of the result of the constantly changing surface—that is to say—the Instrument with chalk cylinder & travelling Pen we have only to record as yet that it fails of its purpose—

We now go back to the small chalk Disks & Platina Point—and find certain results say 200 words per min. On 30 000 ohms nearly always obtainable but not reliably we find that it is not Pressure that is required—but friction created by the pchemical solution in which the chalk is steeped—so that when the current passes & this friction is neutralized by it the normal friction of the chalk alone is active—we this latter by reason of the use of but slight tensions on the springs being slight—the retractile spring is left free to operate with great promptness.

We now proceed to Experiment with this apparatus steeping the small chalks in the solutions recommending themselves as efficient in the properties we require Viz.

Strong Increase of

Strong Normal Friction upon Open current—and Complete Neutralization of same upon passage of current through it—

Our previous notion has been that our normal friction was to be obtained by great Pressure on the Point. We now find this is wrong, & that we must have a normal friction generated by the chemicals alone to the end that it may be neutralized by the current—and the retractile spring have only to overcome
the light pressure of the spring we are by this means enabled to use—

1. Caustic Soda. 2. Gr. Balsam Canada 5 Gr. Caustic Potash 2 Gr. 100 cc HO No good—
2. 5 Gr. Balsam Copaiba 1 Gr. Caustic Potash—100 cc HO No good—
3. 5 Gr. Gum Guiac5 5 Gr Caustic Potash 100 cc HO no good—
4. Caustic Potash—Gamboge. Sesquichloride of Iron 100 cc HO no good
5. 8. Gr. Bi Carbonate Soda. 100 cc HO. no good
6. Got led off into general Experiments with the point of the pen. Tried it shovel shaped thus — but found Fluff would collect underneath it & destroy action— Turned the same point perfectly upright thus — also failed — then twisted it to a position at right angles thus — so that it travelled edgewise — This apparently works very well— but may be found less effective than a point.

Tried on these various points various solutions of Gamboge Caustic Soda & Caustic Potash—as follows

Saturated solution of Caustic Potash Soda & Gamboge Caustic Soda & Caustic Potash—Alcohol & Gamboge Caustic Soda & Pepsin &c &c Getting very fair result. But not at all satisfactory—

We tried placing a piece of paper upon the chalk—& found good results— Immediately following them up & steeping the paper in a solution of Caustic Soda Gamboge 100 cc HO by nice adjustments we got 250 words per min. Perfect on 36,000 ohms—good.64


1. See Doc. 783.
2. See Doc. 784.
3. See Doc. 783.
4. Actually, “the results of the latter” statement in the above paragraph are in Doc. 783 and preceded this entry.
5. Guaiac (or guaiacum), a resin.
6. The following morning Edward Johnson noted that “We find great difference in Paper—some Papers giving good results others failing to operate at all—.” The staff then tested a number of papers using a solution of 5 g caustic soda, 5 g gum gamboge, and 100 cc water. At 11:30 a.m. they concluded that the best paper tested to that point was J. F. Luhm & Co. chemical labels. Cat. 996:40, Lab. (TAEM 3:299).
To Norman Miller

[Menlo Park,] Sept 6 [1876]

N C Miller

Yours rec'd. just as soon as I get me new Acoustic Insts\(^1\) finished will invite Mr Van Horn down. I had previously been experimenting with a rather rough kind of apparatus & started some time ago to make a complete set. as I have only 2 men, and not much money it goes slow=\(^2\) Yours

Edison

ALS, DSI-NMAH, WUTAE.

1. Docs. 773 and 795.
2. Edison's labor records of work on the acoustic for the week ending 8 September indicate that there were two full-time machinists and a third machinist working half-time. 75-020, DF (TAEM 13:731).

Notebook Entry:

Electromotograph and Telegraph Recorder/Repeater

[Menlo Park,] Sept 7 1876—

New system based on the Electromotograph. first I propose to use Morse registers or other means such as a magnetic engine to move the strip of paper along and I arrange a single punch & mechanism on the lever of the register which is moved by a magnet in a local circuit operated by a key. This little punch is vibrated with immense rapidity in the same manner as the needle in the electric pen & with similar mechanism = & the whole is so arranged that when a message is sent on the key the lever will bring the punching devices in play & punch hole in the paper instead of embossing the characters as when the register is used in the ordinary manner = . This punched strip is then taken to the transmitter which consists of a platina faced drum rotated by suitable mechanism & the paper passed rapidly through it & the contact roller serves to open & close the circuit & transmit the characters to the distant station. It is there sets\(^3\) in motion the lever of the Electromotograph which responds to several hundred words per minute this lever opens & closes the circuit of a local battery & local Electromotograph whose lever moves with great force this second lever serves to bring into play a perforating apparatus similar to that employed in preparing the transmitting slip this reproduces the messages on a strip perforated. this strip is then passed between a point & drum; rotated slowly and connected to a sounder & the operator copies the message by sound\(^1\)

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ADDENDUM

[Menlo Park,] Sept 29 1876

Another form for transmitting[?] puncher

July–September 1876 129
Specimen of transmitted & reproduced perforations.³

T A Edison                      Chas Batchelor
                                  James Adams


1. Five years earlier Edison had proposed using vibrating punchers in automatic telegraphy. He had also conceived a system in which receiving punchers were used to record messages that then operated a printer, rather than sounders as proposed here. See Docs. 151A and 194.

2. Figure labels are “pen,” “line,” “Local Emg,” “Earth,” “pen,” “Line,” “ground,” and “main, line, E.M.G.”

3. Over the next several days Edison designed new levers for the electromotograph (see Doc. 792) and devised alternative puncher plans, including one using a tuning fork like his proposed acoustic printing telegraph (see Doc. 782).

A paper-tape puncher powered by a tuning fork.

A note of 12 September indicates that Charles Wurth was beginning to make a “complete magnetic puncher” (Cat. 997:19–25, Lab [TAEM 3:361–64]). This instrument probably resembled the mechanism shown in Edison’s U.S. Patent 200,994 (a perforator and transmitter similar to these designs, but not employing the electromotograph), which application he executed on 30 October 1876.
In this perforator/transmitter, the paper tape leaves the motor-driven puncher (figure 1 and at left in figure 2) and feeds directly into the transmitter (at right in figure 2).

From Pitt Edison

Port Huron, Mich, Sept 11 1876

Dear Bro

Your received Wastell informs you that the GTR has commenced suit they did the amt they suid for was $1400.00 and at the same time the GTR owed the StRR Co about $1000.00 on Cartage and $208.00 on mail and I did not think best to anoy you as the diffences could and has ben all ar ranged to the satsisfaction of both partys what Wastell wants is to destroy any confidence you have in me in the management of the StRR he boasted the other day that he started in to bust the old road and by G he would do it there will be nothing verry arlarming happen the Road with out you knowing all about it in time so let Wastell write and send me his letters so I can keep posted on his movemets he is as much of a enemy to the road as he ever was About Stewart buying the $250.00 in the Sarnia road he bot it fare and
square as he ever bot a hat but he supposed before the note became due he could sell at par he did not sell and he wanted to forse me to take it and thare is whare his mad comes in

I see that Wastell wants to make you believe that the road is all agong to the devil and make you sick and get you to take less Gouldens offer was $13 000.00 or the old agreement carried out and so I Telegraph you but when I told him all right he said they would give you the amt with out intrest and wanted me to advise you to take it I told him I would not it would only be a waste of time and I thought you would sinck your stock first did you get the statemts

Atkinson has gon east thay said he would see you


1. This may be related to the Grand Trunk Railway's subsequent effort to remove the Port Huron and Gratiot Street Railway Co. from its yards. See Doc. 832.

2. Pitt was secretary of the Sarnia Street Railway Co. across the river from Port Huron. TAEB 2:612 n. 2.

3. James Goulden, a liquor and cigar wholesaler, was a shareholder in the competing City Railroad Co. Endlich 1981, 98; Jenks n.d., 8.

4. In a letter of 28 August 1876, Pitt told Edison that Goulden offered $3,000 for William Stewart's stock, but Stewart refused anything less than $3,500, and that Goulden would also "see that the old agreement that is the bonds & mortgage on the road would be carried out in one year if we would pay the difference on $500.00." DF (TAEM 13:1065).

5. In his 28 August letter Pitt stated that he would begin sending Edison weekly financial statements of the Sarnia Street Railway. These have not been found. DF (TAEM 13:1065).

6. Probably attorney O'Brien Atkinson, who was connected with the City Railroad. History of St. Clair County 1883, 554; Jenks n.d., 15.

Notebook Entry: Chemistry and Telegraphy

July-September 1876

Discovery

When Aniline oil is treated with Nitric Acid (fuming) and then thrown into a large quantity of H.O. a precipitate takes place band a yellow coloring matter dissolves in the water; If this be filtered off it may be enormously diluted without destroying its delicacy to electrolysis. If a strip of paper be wet in the solution it gives on the Oxygen platina point a reddish
mark not very brilliant rather dull, by increasing 3 cells carbon battery this mark turns greenish, if you increase the resistance to 1000 ohms the mark is green when formed 2000 ohms may be inserted without any material weakening of the mark. But the most remarkable thing is that if to the solution Nitrate of Lime & Chloride of Calcium be added no mark is obtained at all on short circuit & it only commences to appear after 2000 ohms have been inserted and gradually increases in sensitiveness until 10 or 12,000 ohms have been put in. the mark is seen at 20,000. Thus this is probably due to the fact that with a certain battery power the Nitrate of Lime or Chloride of Calcium is decomposable & the constituents prevent the appearance of the mark and it is not until the current is so weakened that these substances are not decomposed that free oxygen is given off at points & oxidizes the Aniline. This opens a new field in telegraphy, as we may by balancing certain solutions, transmit 1/2 of a Roman letter by a weak current & the other 1/2 by a strong current & in many other ways use it even in the dot and dash for we can send a heavy current to make the spaces which will not record & use the weaker current of the static discharge to record.

Good EMG Solution

Nitro Aniline as described on last page mixed with Chloride Calceium HO Solution & neutralized so as to leave excess Caustic Soda this decreases on 20,000 ohms 3 cells Carbon quite plain & increases on .0. Mistake can't felt feel through 20,000 ohms.

Cellulose Solvent

I placed some tissue paper in a bottle containing crystals of chloral hydrate three weeks ago, having noticed that the cork stoppers (which are cellulose) were dissolved by the vapors. I now find that a portion of the paper is dissolved, at least it has every appearance of it, having aglutinized & is somewhat transparent, while the cork also thrown in at the same time among the crystals is unmistakably dissolved. I took the paper out and put in a test tube with alcohol. this didn't appear to dissolve it more; heat it, also put camphor in, also chloroform no increase in solvent power noticed. I have corksor the tube & laid it away & put fresh paper in the bottle. I took some crystals & mixed them with paper & put in a test tube & melted the chloral by heat. it appeared to 1/2 semi dissolve the paper put chloroform in this didn't help it corked & set away put some paper in tube with crystals chloral & Bisulfide carbon. have set it away.

T A Edison

July–September 1876
This entry follows a series of experimental observations begun on 9 September with chemicals that Edison had used in early August (see Doc. 775).

2. Edison used strong and weak currents in his diplex circuit designs. *TAEB* 2:299 n. 6.

3. For Edison's earlier work on cellulose solvents see Docs. 583, 586, 645, and 655.

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**Notebook Entry:**

**Electromotograph**

[Menlo Park,] Sept 14 1876

Electromotograph Experiments for last 5 days.

After trying a great variety of disks of paper upon the chalk, both hard glazed, biblus and high lead glaze; we thought of silk. Cut a washer of very thin silk wet it with a solution of Caustic Soda and Gambooge and laid it on the chalk when the results were splendid and exceeded anything everything tried (papers & chalkly subs) afterwards we tried a number of silk disks & different solution but we did not afterwards obtain such good results as with the first disk of silk which may be attributed to some trifling change in the conditions, = We notice one thing about silk which is different from anything yet tried and that is its beautiful eveness as seen under the microscope; and the great pressure you can place upon the EMG lever without abrasing the surface. In fact the point run in a circle on the silk disk for $\frac{1}{2}$ an hour & with considerable did not shew the circle or an abrasure even when placed under the microscope $1\frac{1}{4}$ power and even when it has been used for 2 or 3 hours, a thorough soaking of the disk caused this circular abrasion or track to disappear. My opinion is that a disk of silk would last for a week at least, which cannot be said of any other substance known to me;

Another curious thing about silk as the rotation is that it only holds the chemical solution in its interstices, the solution not penetrating the fibre itself as is the case with paper and it holds water only by capilliary attraction in the same manner as a little pile of powdered glass would attract & hold water by capilliary attraction

After trying a very great number of experiments we found that the mechanical vibration which on silk laid on a smetal disk & dry is small became great when moistened and caused the mutulation of the signals; We also found that although the
Caustic Soda & Gamboge Solution had great delicacy it could not be shunted to any extent like Acetate of Mercury & Caustic Soda or potash which is attributed solely to the fact that it slips on Oxygen whereas Acetate of Hg & Caustic Soda or potash increases friction on Oxygen thus with the Gamboge solution a dash is sent with one current lubrication takes place & when the Counter charge of the magnet comes it also lubricates so in this case compensation by a reverse current does more harm than good in fact prevents the EMG from working while if we use Acetate of Hg & Caustic K or Na thewe may shunt it with a magnet extraordinarily low as in this case the counter current acts to increase the friction & we thus get double the working difference besides allowing of the use of a Condenser & thus cutting out constant currents. However after finding the important part played in mutilating signals and rendering reeven results pecarious by the uneavness in friction of smootened substances it occurred that theris might be compensated for by securing to a shaft several independant leves provided with platina points & resting upon the disk of material each leave lever being held down by a spring and working entirely independant of othe others yet all serving to give motion to the lever which closes the circuit. A drawing of this device is shewn on page 23, Vol. 5 we had it made and although made in a very crude manner it gave great deal better results than with the inferior solution we were using than any arrangement yet devices. The theory of using several independant levers to obtain an even friction was this that any bad spot on the disk would entirely destroy a dot or dash if one point were used or one half of the disk might be wetter than the other half ie from edge to centre; ancausing say ½ doz words to come heavy & ½ doz light whereas with several leves a bad spot wacting on only one lever would be insufficient to give a false signal it being necessary that the bad spot should pass at least under 2 if not 3 levers; and if one half of the disk had more friction than the other othe other half will have more hence 2 leves may be on a less & 2 on a more frictional surface, hence eveness; but we found that owing probably to the inferior manner in which the lever were made & their loseness upon their fulcrom the run about on the disk.

We then changed the style slightly and made a 4 sprin pronged spring as shewn on page .20. Vol 5. This worked beautifullv smooth on dry silk= We had previously been out of acetate Hg & having recd 2 oz we made a solution with
Na. & K and henceforth use it = ie Na Acet-Hg = found that on wetting this dry silk mechanical vibrations came in quite strong = and this proved that the four points did not give enough compensation which we attribute to the fact that they are all rigid together and if one lifts by a piece of acetate Hg or grit it tends to lift its neighbors thus decreasing the total friction which was not the case with the four lever = and another thing which militates against this form is that the material passes under each point at different rates of speed and a bad spot in the inner spring would not be so effective in mutilating as on the outer as the latter moves faster;

I believe the relay lever style is the best, but the springs should be separate and run independent all the way to the lever and have their pressure put on their ends & at the same time be arranged to run all or nearly so in the same channel & nearly equidistant from the centre;

While experimenting with this form where there was considerable mutilation of Signals with silk laid on platina faced disk & moistened with thick black curdy AcHgNa-Solution— and we could shunt on 140 ohm WU relay & 500 ohms through 25 000, 26 cells old Carbon; no sending shunt & get occasionally good words at 100 wds per minute speed. Having tried an experiment previously of allowing a point to run on a silk dipaphram with only air underneath and noticing the the absence of mechanical Vibrations it occurred that perhaps the silk laid on too hard a substance we then put a piece of ordinary chem paper moistened with the Reg solution under the silk so as to allow of a give, the results we striking Mechanical Vibrations nearly ceased and with a single spring pressing on silk, we could receive nicely at about 100 per minute through 25 000, 26 cells carbon old = shunted with 140 ohm WU Relay only = and with 800 plain & relay we could receive at 200 wds per minute 100s of feet without a bug or bad signal thus giving best results ever obtained on the E.M.G. Hence it is proper to infer that 1st silk is the best for a surface of all substances yet tried

2nd that Acetate Hg & NaO. is the best solution both on account of its delicacy & increase of friction on .O. by reversing the current

3rd that a giving bibilus substance must be placed under the Silk. th

4th that several levers or spring all independent of each other with pressure on their ends and each sufficing to move the contact lever and all arranged so that the are in a same
Edison described this electro-

mograph as a "disk run-
ning in a thick muddy solu-
tion of Kaolin & acetate
Hg & Caustic Soda."

distance or nearly so from center of disk—
5 that the points on these levers or spgs should be as small
as possible and be very smooth.
6th that the relay lever movement is the best
7th that the slower the engine runs the less the effect of
mechanical vibration;
8 That great care should be taken to eradicate all fric-
tion & shake in the mechanical moving parts.
9th To put the solution even on the silk & to use it
quite dry=
10 to obtain your normal friction by the use of a chemi-
cal & not by excessive pressure;

Weith the spring 4 points silk & paper underneath we stat-
icd the line with 60 sheet of condensr at sending end and re-
corded direct on auto paper at speed that couldnt read owing
to weakness & tailing & which could not be shunted= with
F.M.G. under same condensters we could get it fair at same
speed and sometimes roos of wds without a mutilation
shunted with a WU Relay & 600 ohms=

We are now trying a little side experiment placing a cup on
disk with a hard rubber centre (.page 24 Vol 5)* & shalft with
disk running in cup in which is a muddy solution of Kaoline &
the Reg Solution. This will give a beautiful Smooth friction &
if there is any working difference it will be OK'= I will men-
tion that the disk is of brass whereas it should be platina to
give it a fair trial=

ADDENDUM*

[Menlo Park,] Sept 14 1876
We* have just finished trying the dish, with a Smuddy
(thick) more like butter;) of Kaolin & Reg HgNa Solution in
which the brass disk runs we get a very strong movement of
the disk with six cells on short circuit but scarcely th'any with
150 ohm ie* through it = The surface was probably too great
besides the surface was brass. OTo obtain proper friction had
to run engine rather fast= Noticed one thing & that is that
lever is sluggish it closes rather quick but normal friction dont
"catch" quick enough to draw it away rapidly it being
mushy "gives" whereas if it was ridgid stuff such as paper it
would get its normal friction instantly= it proves one thing
and that is that a galvanometer could be made with an im-
mersed disk in a Liquid of Considerable Specific Gravity.
Afterwards we disconnected disk and let wire connect-
ing disk with point lever rest in mushy stuff the action was

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much more delicate & rapid, & was sufficient to work moderately well through the 150 ohm relay thus

This also proves that you must use small surfaces to concentrate your action on the smallest point that it is possible to use. We are now trying what I think is going to be a success; thus

on the end of X is a long platina point with a small ball of cotton or other giving substance covered with silk tightly and wet with the regular Solution it resting on a highly polished platina disk with this giving point and a highly polished disk perfect even friction ought to be obtained & with great difference = EHJ is now making it=

We have just tried it and it works very well. The bag flattens out owing to pressure and this causes after few moments an uneven friction but the first few moments gives, absolute even friction. Could this bag be made to stand longer or could be easily changed it would be Valuable but E.H.J has gone back and made the last arrangement which gave such good results thus
This works very nice has some bugs but current wipes them out. A disk of paper moist but rather dry is laid on platina over this is laid the silk tightly drawn the silk is then covered with a thick paste of the Acetate of Hg & NaO, which has just sufficient moisture to reconnect the paste through the silk with the paper underneath. This paste surface ought to be polished, but after a few moments the point polishes a groove which if it shines all the way round gives even friction, but gives a false mark if a portion is seen to be unpolished still this false jerk is weak & current wipes it out.

We notice one thing very prominently with 6 cells through 150 ohms shunted with a 12 ohm sounder giving reversals the margin is considerable & when shunt is disconnected and all the Current passes through paper the working difference is greatly reduced. Whereas if the reverse current performed no function it should be stronger as it gets a full current. This is what makes the Acetate of Hg & NaO Solution so invaluable.

T A Edison


An electromotograph with three independent levers.

2. They made this on 11 September. Edison noted it was a "new style lever we are putting on today." Cat. 997:20, Lab. (*TAEM* 3:362).
ACOUSTIC Transfer System Octuplex

Last night got the new set of local forks set up for working 8 messages. the forks especially the high on work beautifully, but the others do not work so even one making an excessive amplitude and striking the magnet which if it is not allowed to do gives scarcely sufficient amplitude but the other one does not give sufficient for perfection. Even when striking the magnet (caused by shortness of wand) & one weight has to be set ¾ inch ahead of the other to balance; this is not so on the one that gives great amplitude, but perhaps it is due to the working of the low resistance magnet of the high forks with the high res magnets of the low forks & difference in battery on one fork & the other. the connections had to be made as follows on account of the difference in resistance of the two magnet.

X magnets have together 24 ohms while theose on the high forks have only 6 ohms; this gives them an undue advantage especially if there is much internal resistance in batteries. if both are in one circuit X works with great power but high fork magnets do not work.

We adjust up and found had connections wrong. Changed it= then found that spiral connecting wires kept breaking fixed them, then found 368 cells carbon at one end would scarcely move the common WU 140 ohm relays. increased its effect by shunting relays with 3200 ohms thus causing discharge from magnets themselves to bridge over space between waves, still too weak, put on NY battery which was very weak this made it about same; added our this made it stronger got it on one; found bug in transmitter at semireceiving.
end fixed, got it on .3 but couldn’t get it on other wires kept breaking on forks. We are now engaged in obtaining & testing continuity by a sounder, closing proper points with a metallic wedge;

T A Edison

X, NjWOE, Lab., Cat. 996:56 (TAEM 3:307). Document multiply signed and dated. "Written in margin; index points to "striking".

1. This entry is continued in Doc. 795.

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From M. Fleming

Dr Sir

Adams’s Prest. is confined to bed so cannot at present transfer Stock. I have made enquiries about your Port Huron matter. Do not think those parties will come to any arrangement. They are afraid of each other and each man has a poor opinion of the others honesty. Stewart is so peculiarly constituted that is not easy to get him to talk business. He has gone completely back on your brother & says openly he will not touch anything Pitt is connected with to such an extent does he carry this idea that he yesterday sent me Five shares of Sarnia St. Ry. Stock to sell for his account at any price no matter what that it would sell for. I told him that I could not sell at all the amount being so small and the credit of the Road bad however he insisted on leaving it with me. Pitt does not somehow seem to manage well. There are so many dunning or suing the Road makes things worse. W. B. Clark has put a Six Hundred Dollar claim in suit. Wiley of the Grand Trunk tells me they are suing for some Nine Hundred Dollars Ticket and Freight money. Chalmers holds note past due for about $200. C. MacKenzie note $125. R & H MacKenzie 230.33 Jas. Lowrie note $50. Stewart Pt Huron $123. and about $200. for rent. So you see there are pressing debts amounting to $2500. besides monthly notes falling due to G.T.R for Iron $150 and interest but I believe they are paying those latter notes as they mature out of the earnings. When Executions issues against the Road they will demolish its credit completely. In its present condition I would not care to undertake the management of your stock. If the liabilities were paid then I would consent to accept the proxies for the purpose of seeing that the Road was managed in your interest that is honestly and economically worked. Cowan told me that some man was trying to buy the Road. If that man would
offer anything near what stock cost, I would feel inclined to let him have Major Clark's $2000 but I do not think there is much chance and that Cowan sees thru Pitts spectacles. You had better come on here and stay long enough to satisfy yourself how the Road really stands and what money is necessary to end its troubles. If Pitts stock was paid for there would be plain sailing. I shall see those Pt. Huron people before long and let you know result. Yours Truly

M. Fleming


1. Joshua Adams was president of the Sarnia Street Railway Co. Agreement between Sarnia Street Railway Co. and Grand Trunk Railroad Co., 29 Dec. 1874, DF (TAEM 13:29).


3. Unidentified; see Doc. 835.


5. Probably Charles MacKenzie, an incorporator of the Sarnia Street Railway Co. Ibid.

6. Unidentified.

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[Menlo Park,] Sept 17 1876=

Acoustic. Continued from page 57.

We found that the continuity test was OK but the trouble was all caused by Gilliland giving us a wrong diagram of the connections. We straightened this and then found the side that was it better and we succeeded on short circuit in balancing and sending in opposite directions even when all the other keys besides the ones sending were closed or open = We then tried it on Philadelphia and it worked about as well, 4 sheets condenser = We then closed for the night and Adams then in PM run the lose connections on table nicely = we then started again worked several hours and I then discovered that he had misplaced one of the wires, rendering it impossible to balance one end while the other was OK = having got this OK we worked fairly although troubled with want of battery power = I then changed the method of operating the controlling forks & line

I placed in a local circuit one of the old low forks, used one prong & spring to open & close its main own circuit, and the other prong with two springs & points one to close the line

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Notebook Entry: Multiple Telegraphy

July–September 1876
containing high Resistance magnet forks and the other to close a local containing the other high resistance magnet forks. After making this connection found that the other local forks worked even & nicely at both ends which is not the case with the 4th old way, the reason of which has already been explained, but could not get anything through the line at either end — closed — next evening. This evening started forks with 60 cells carbon (Little battery) each end found circuit ok, but couldn't balance well yet could work on all four without mixing, found that the timing was very much out—readjusted controlling forks and got nearly even—current increased in strength and we succeeded for the first time in sending eight messages over the one circuit, a feat never before accomplished with morse apparatus. 800 ohms was in the line. Owing to the fearful storm we are unable to get our Philadelphia Loop — I predict that this apparatus will require about 400 cells of Callaud at each end in a 300 mile circuit. The Quadruplex requires 200, but with this do battery several lines may be worked out of the same battery so the excess over that used in the Quad does not amount to much in fact it is economical. besides 8 messages is the product aI also predict that this apparatus will work better & have more margin than the Quad when it shall be improved as much as that apparatus.

After Running for four hours we put main battery in and find circuits OK; Put 1600 ohms in artificial line with 2300 ohms and as there is 700 in each side bridge making 350, and Relay Resisn is 240, this makes bal correct according to resistance. We send on all 8 keys & all comes clear on 8 Relays — We now shunted line (not to Earth) with 75 sheets cond'r takes 48 to balance on artificial. We now put condenser in centre of line. 800 ohms each side & ground other end and find that we get everything clear requires no change in resistance but only requires 244 sheets cond'r at each end to balance;

X, NJWOE, Lab., Cat. 996:60 (TAEM 3:309). 4 Obscured canceled letters interlined above. 5 Obscured overwritten letters. 6 Multiply underlined. 7 Last two words underlined twice. 8 Repeated at end of one page and beginning of next.

1. This entry is a continuation of Doc. 793 and is continued in Doc. 797.
2. Edison may be referring to the circuit shown in Doc. 773, which “Worked Bang up Sept 17,” but also see the circuits shown in Cat. 997:13-15, Lab. (TAEM 3:358-59). At this time Elisha Gray was in New York demonstrating his eight-message electro-harmonic system on Western Union wires (see Doc. 786 n. 4).
3. Difference in current strengths.

July—September 1876 143
My dear Sir

Thanks for your letter of 29th ulto—\(^1\) I think it must have been delayed in transmission—I am also still without the details of price which Mr Batchelor promised me.—

I have had a great deal of trouble with the first lot of pens (5) owing

1st To the rollers pins all working out—
2nd To two of the Pens working very badly.—
3rd To the ink being very defective & light in color.

Of course I did not at first know what was the matter and dare not send out pens till all was in order— The Second lot are all right but badly packed—i.e. Three pen boxes are entirely without fittings—7 others have no files or screwdrivers—none have extra needles or cords—Three presses have the clips—i.e. the folding part—smashed—one before make four— Please send me spare ones to fix on

The Second lot of Ink is blacker but I could wish it blacker still— I send you specimens of writing— No 1. is your first ink 2. your Second 3 is ink used by Clare—he says \(\frac{1}{2}\) printers and \(\frac{1}{2}\) Castor. —I cannot get this to work—

Can you suggest anything that will answer & give deeper color.— It seems almost essential here— Your screw drivers are too weak. Cannot you make them stronger.—

The cords wear out very fast— Please send an extra supply—say 100 and say where they can be had here—\(^2\) if you know— We have already competition by a Pneumatic Pen—which works a needle— I think it is an infringement—if not it will be a serious competitor.— We have given notice.—\(^3\)

I wired you stopping supplies until I could call your attention to the above matters—especially ink Yours very faithfully (In haste)

Frederic Ireland

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1. Not found.
2. Ireland probably meant “here.”
3. On 11 October, Ireland again wrote Edison about the pneumatic pen and informed him that the inventor’s name was Pumphrey (DF [TAEM 13:980]), possibly a Josiah Pumphrey of Birmingham. Although no Pumphrey patent has been found for a pneumatic pen, he did take out American and British patents for a copying process (U.S. Pat. 200,759; Brit. Pat. 895 [1877]).
between Sept 17 and this date we have been trying Various experiments and find that owing to the magnet discharge our plan of overcoming the excessive resistance of the magnet of the hilow fork and the low R of the high fork by connecting thus

is a failure as the discharge from the magnets are unequal that from X being the greatest hence C discharges instantly the extra current from X passing through it in a contrary direction while X is prolonged by its own extra current This necessitated a great change in the controlling fork springs as more or less battery on the local forks generated extra current of different strengths. We obviated this by using only one spool on each magnet of C and connected both it and X in the same circuit thus destroying the closed circuit in which the extra current could circulate and do mischief = We also tuned the forks so that they would start of their own accord when the magnets were some distance away I find that the tension on the contact springs and the portion of time when the fork is touching and not touching is an important factor in keeping all the forks in unison; to obtain a perfect unison the springs should be in contact with the forks all the time, and the tensions should be very nearly alike. I also find that tuning forks may be adjusted to any rate by a spring pressing against their end, instead of weighting them. We now have the two controlling forks in the same circuit which ckt is operated i.e. opened & closed by a spring & point on a low fork local, and I have the switching fork local points adjusted alike on both forks so they close simultaneously and I find this to be correct and the ckt didn't change last night at all after we made the change of C. & X.

Having got the unison practically and theoretically Correct and reliable, we find can do first class work on Resistance line with 80 cells Callaud each end with 2 3 4 5 6 or 8 thousand ohms ion = But when we attempted to work the Phila loop
120 miles we found that the static charge invariably changed the circuits throwing No 1 mesg on No. 2 Relay & No 2. mesg on No 1 Relay. I can only account for this by supposing there is a retardation of one pulsation or the 1/120th of a second, in the passage of the current. this would do it. Allowing this I could get 4 message at either end fail fairly but couldnt balance fine enough to get it clear although you could read it, but taking in consideration that there was very considerable escape and there was only required 1000 ohms to balance & we having only 780 cells Callaud this was a good showing. We ought to have had 3 times as strong a received current and as you can balance a strong outgoing current as finely as a weak one the interference would not bear so near the strength of the reed current. We use back point relays now and close the sounder by stopping of the current. We think it works better. Repeating Sounders appear to improve signals but they are hard to manage;


1. This entry is a continuation of Doc. 795.