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The sending of messages at the same time through one and the same wire

by Werner Siemens

As far up as 1849 in company with Halske I occupied myself in solving the problem how to send through one telegraphic wire a number of simultaneous dispatches exceeding the number of wires. We started from the following considerations:

If the extreme end of any wire be connected with the extreme ends of all the other wires by means of a telegraphic instrument with appurtenant Battery then $\frac{n(n-1)}{2}$ of such a telegraph apparatus may be put up on each side of the n wire which connects offices A and B. Now, when the appurtenant Battery is inserted in ~~the~~ one of the inserted apparatus between the respective wires, then all the wires and apparatus present get run through by a ~~+~~ more or less powerful currents. The Question now is ~~the~~ to make the current which passes through the homologous apparatus of the other station as powerful and active as possible, & on the contrary, time, the current which passes through the remaining apparatus either very weak or to compensate their action entirely or almost so. - This may be done By a proper selection of resistances, which had to be ~~accele~~ put in or out in the Batteries and apparatus through local by-closings of the active batteries, and through a proper construction of the instruments.

As the calculations made for a small number of wires as well as the experiments made promised very satisfactory results, so we took up in a patent issued in England 23 October 1849 our claim in simultaneous sending of a larger number of messages by ~~[illegible]~~ wires. When we further occupied ourself in this matter we found out very soon, that the solution with a larger number of wires became too knotty and complicated, and that the principal requisite of telegraphic arrangements (the greatest possible surety) could not be reached satisfactorily.

Some years afterwards Mr Dr Krause in Arllenburg tried to solve the problem of manifold simultaneous use of telegraphic wires in a quite different way. In his experiments he made use of a modification of the dialtelegraph, constructed on the principle of Neeff, which consists in its being connected with a relay. This is done so that the coils of the relay to be traversed by the line current, — the coils of the telegraph magnet by a local current, whilst the contact of the relay alternately produces and interrupts the local current, — and that of the telegraph does the same at the line current. So arranged the dialtelegraphs are enabled, by means of very short and weak currents which pass through the line and the coils of the relay, to work safely and rapidly.

Now just fancy any number as you choose of such combined dial or printing telegraphs put up at each end of the line. One of ends of all relay-coils communicates through the screw-contacts of the appurtenant telegraphs throughout with one of the poles of a common battery, whose other pole goes to earth. The second free end of each relay on the contrary leads to an isolated contact spring = spiral. These springs are at an equal distance grouped around a contact-disk. The rim of this disk, on which the springs are dragging, is so divided in alternate isolating and conducting fields, that but one spring continually is in contact with a conducting spring, all the others on the contrary with isolating fields. When the disk is turned round, then the springs successively for a moment get in conducting connexion with the disk and through it with the line wire. Suppose now on both ends of the line the same arrangement made, both batteries inserted in the same direction, and both disks exactly as uniformly turned around, then all the telegraphs will rotate uniformly. If one of them gets stopped, and hence the conducting connexion of its contact spring with the battery permanently interrupted, then ~~[illegible]~~ the apparatus of the ~~next~~ other station, ~~that is to say~~ connected to it with a homologous spring must stop likewise, as no current can pass through the line, while this spring is connected with it. The uniform rotation of both disks is accomplished by Mr Kruse by providing it with teeth, and making it turn around out of itself through the oscillations of the telegraph-magnets. As on both ends of the line there are always the same number of apparatus are in motion, and every one of them are rotating with exactly the same speed it results that both disks get on exactly uniform. When single pairs of telegraphs are stopped, then the speed of rotation of the disks is decreased through it, and consequently also that of the remaing telegraphs, but the uniformity of the rotation not disturbed.

It is evident that this ingenious combination for practical use is too complicated and too unsecure. especially it would be very difficult to make the relay so sensitive and to give it so much speed, that it would be possible ~~[illegible]~~ to operate surely and put the telegraphs in motion, when it was provided only with currents of such short duration.

In the second Decemberedition of the Leipzig
1854 polytechnical Central Journal the Inspector of Telegraphs Mr Galls gives a description of a method ~~[illegible]~~ by Dr Gintl on the line Prague - Vienna by means of the Morses Writing telegraph to send simultaneously dispatches in opposite directions. It is so made that the relay magnets are provided with two spirals of which one of them did communicate with the linewire. If the key (contactlever) be not depressed, then its resting contact formed the conducting connexion of the free end of this spiral with the ground, the conducting circuit consequently was established through the wire, the respective spirals of both endstations and the ground. By depressing the key of one of them the direct conducting connexion of the spirals with earth

was raised, and on the contrary the same established with the free pole of a battery conducted to earth. Consequently the current of this battery now passed through the linewire, and the spirals, which form its continuation. In order to prevent now this current to magnetize the relay's magnet present at the spot of the active battery, another contact is simultaneously formed by the same lever motion which caused the course of current of another battery through the second spiral of the magnet. The current passed through these spirals in an opposite direction and becomes so much equalized through a rheostat there inserted, that its magnetising action gets equal and opposite to the line current which passes through the other spirals. The relay magnet of the own station consequently remained entirely unmagnetic whilst the current exercised its full power on the magnet of the receiving stations. If now this same arrangement had been made on both ends of the line, and both contactlevers got depressed simultaneously consequently all four batteries inserted, then the equilibrium of the currents in both relay magnets gets disturbed and the armatures of both must be attracted. Hence each apparatus must receive the signals given from the other station, whilst simultaneously other signals went out from it, and appeared there

It seems that Dr Gintl has inserted the batteries on both extreme ends of the line always in opposite direction, and has considered this to be absolutely necessary, as he afterwards often has expressed the strange opinion that the possibility of Counterspeaking demonstrated that two currents may pass one wire in opposite direction, without weakening or destroying one another! In the present case it is exactly the same for the size of disturbance of the equilibrium of the magnetizing actions of the currents which pass through both spirals of each relay-magnet in which direction the batterys of both Stations are intercalated. If they are intercalated in the same direction, that is to say in such a way that they act as a ~~one~~ battery of the double number of elements, then the strength of current in the wire and the spirals connected with them double as large as that, which is produced by a single battery in the same circuit. If on the contrary the batterys are equal and in opposite directions, then they neutralize each other in a completely isolated circuit entirely, and no currents gets neither through the wire nor the appurtenant spirals. ~~get~~ In both cases the magnets ~~[illegible]~~ are magnetized through the difference in action of the line and the equilibrium current, consequently just as powerful as in a one-sided current — The only difference is that in the first case the line current, in the second the local equilibrium current is predominant and performs the magnetizing.

The practical results which Dr Gintl obtained in experimenting with the herebefore mentioned apparatus could only be very unsatisfactory. Two batteries do not remain very long in equilibrium, without frequent corrections of the resistance. Still far more difficult, yea almost impossible it is, to make and unmake really at the same time two contacts, as this is required with Gintl" counterspeaking proceedings. Moreover the connection of the wire with earth during each passing from one state of rest to the other is interrupted, the current arriving from the other station consequently raised during this time through which necessarily disturbances of the arriving current are caused. Finally Dr Gintl has, by intercalating the batteries in opposite directions, ~~still~~ added caused the trouble that the relay magnets in simultaneous writing in the direction of equilibrium currents, on the contrary on onesided writing in the direction of the linecurrents get magnetized, at each of the numerous changes between single and double writing hence the magnetism of the electro magnets ought to be reversed, whereof the necessary result is that frequently small writing signals kept away entirely, and larger ones got interrupted.

The unsatisfactory results which Dr Gintl obtained with regard to counterspeaking in electro magnetic way, caused him to leave this way entirely, and to try the solving of the problem by means of Bain's electro chemical Telegraph. In a ~~lecture~~ lecture delivered the 30 Nov 1854 in the Royal Academy of Sciences in Vienna Dr Gintl tries to give the proof, that two currents, without their disturbing each other, pass in an opposite direction the same wire; that consequently each of both currents which were simultaneously progressing through the wire arrived at the opposite Station exactly so as if it had been conducted alone by itself in the wire; and founded on this imaginary proof the construction of his electro chemical counterspeaker. Although this proof as so evident appears to be perfect erroneous, and only shows that Dr Gintl has left out of all consideration Ohm's Laws, and the doctrine of current branches, still the ~~way~~ route of counterspeaking in the electro chemical way on which he put the first step is very interesting indeed. Hence it would be most appropriate by a simple calculation ~~both~~ to fix the conditions of ~~said~~ electro chemical Counterspeaking right here, and to enter no further in Gintl's proofs

In Taf 11 fig 6 a. b represents the wire, c. d the connection through earth which we looked upon as to be without any resistance, through which both Stations A and B communicate with each other. The connection between a. & c, as well as between b and d is made through the paper slips which are intended to take up telegraphic Signals, and are previously soaked in one of the well known salt solutions, and through it the galvanic circuit closed. If now one of the two offices for instance A inserts a battery $\mathfrak{E}$ into the circuit then, then the current will pass through both paperslips, and on both Stations cause a analysis of the electrolyte wherewith it is saturated. The problem of counterspeaking requires on the contrary that only at station B a decomposition be caused and consequently the paper slip at Station A be traversed by no current. This may be caused by so inserting simultaneously with battery $\mathfrak{E}$, a second battery $\mathfrak{E}'$ together with a as yet to discover resistance w' between both metallic pivots, which serve as anodes, between which the paper slip is carried through, — that the paper slip forms the branchwire which does not get passed by any current in Wheatstone's currentnet. If $\mathfrak{E}$ and $\mathfrak{E}'$ indicate the electromotive strengths of the intercalated batteries, W the resistance of the wire between A and B, w' that of the branchline with battery $\mathfrak{E}'$, W" the resistance of paperslip, i, i' i" finally the current strengths ruling in the resistances w; w' and w'', then is according to the Kirchhoffs form of the Ohms Laws, when through the drawn arrows the direction of the current is fixed:

1/ $w' i' + w i + w'' i'' = E + E'$

2/ $w' i' - w'' i' = E'$

3/ $i' + i'' = i$.

Hence it follows for this case, that $i'' = 0$ would become

$$E : E' = w + w'' : w'$$

Consequently no current at all pass through the paper slip if the resistances of the main and branchline be in proportion as the electromotive forces of the appurtenant batteries. If now Station B simultaneously with Station A inserts its two batteries E and E with the even to equalized resistance w' in the same way, then the two current are to be looked upon whether the batteries of both Stations strengthen each other, or are opposed to the one to the other. In the latter event the line ab is crossed by no current, as the electromotive forces in A and B are equal and opposed. But through the paperslip at A and B auxiliary closings of the equilibriums battery E' are carried. The former consequently are run through by a current

$$i'' = \frac{E'}{W' + W''}.$$

Consequently a decomposition of the fluidity ~~occurs~~ with ~~which~~ which the paper slip is saturated occurs simultaneously on both Stations, which however is not the result of currents, which pass together in the wire, but is occasioned by local currents of the equilibrium batteries. (1)

Note (1) Mr Zantedeschi in two lectures delivered 16 July and 6 August of the preceding year in the Paris Academy of Sciences has claimed the credit of having shown the simultaneous passage of electrical currents of opposite direction in the same wire as early as 1829. His ~~[illegible]~~ demonstration is pretty well similar to that of Gintl, and ~~[illegible]~~ like the latter in contradiction with Ohm's laws. Even if it does not seems fit in these pages to enter into a special refutation of ~~[illegible]~~ such unfounded hypothesis, which are not called forth by any novel, until then not to be explained phenomena, — still it is to be regretted that its putting up has not been denounced immediately, as this has been the cause of great confusion of opinions in several spheres. That two equal batteries put up on opposite direction in a conducting circuit really are inactive is proven by the fact that no heat is produced in the connecting-curve, as the development of heat necessarily is conducive of such a current which overcomes a resistance, as well as by the fact that no chemical action takes place in the batteries, without which just as little a hydro-electric current can be thought of.

When the batteries of the two stations are not opposed, but equally directed, then weigh these equations

$$1)\ w \cdot i + 2\, w' \cdot i' = 2\,(E + E')$$

$$2)\ w' i' - w'' i'' = E'$$

$$3)\ i' + i'' = i$$

$$4)\ \frac{E}{w + w''} = \frac{E'}{w'}$$

of which follows, when i, i' and E get eliminated

$$i'' = E' \quad \frac{w' + 2\, w''}{w \cdot w' + 2\, w' w'' + w \cdot w''}.$$

Consequently also in this case a simultaneous decomposition on both paper slips takes place, which is caused by the predominant current ruling in the wire

In order to obtain a faultless telegraphic writing, the strength of the current which passes through the paper slip must be the same at single as well as when doublespeaking. Consequently in the first case considered it ought to be

$$\frac{E + E'}{w + w' + w''} = \frac{E'}{w' + w''}$$

This equation is only accomplished by putting $w' = 0$. Only then a uniform and sure writing can be obtained, when the resistance, which ~~is opposed~~ to in the inserted paperslip is opposed to the passage of the current, in comparison with the remaining resistances is very little.

The same result is obtained when the batteries are intercalated in the same direction, from the equation

$$E' \cdot \frac{w + 2w''}{w \cdot w' + 2w'w'' + w \cdot w''} = \frac{E + E'}{w + w' + w''}$$

If the decompositions arrangements are replaced by the coils of two relay magnets, then Gintl's current scheme is very suitable for counterspeaking with electromagnetic Telegraphs. but here the trouble of unlike currents in single and doublespeaking is still more injurious than in the electro-chemical apparatus.

To the practical usefulness of Gintl's counterspeaking method, which we have described just here is opposed especially the trouble which is attended with the construction of double-contacts, which should work simultaneously and without interruption of the line. Especially the electro-chemical Telegraph is only fit on single lines without any branches, as it does not allow any repeating (that is to say the mechanical further transmission of a dispatch through the receiving apparatus)

Repeater spoken of.

In Summer 1854 Halske and I, and independently from us the Engineer of Telegraphs Mr Frischen in Hannover kept ourselves busy to give the counterspeaking with Morse telegraph a practical effective form. We were completely-successful in this, and well in materially the same way.

In Current scheme Taf 11 fig 7 suppose a. b the wire which connects offices A and B, m and n be both spirals of the relay magnet covered by two wires, o the key (contactlever) of the apparatus, E the battery, w a changeable resistance, p the metallic plate which forms the conducting connexion with the earth. The connecting lines are conducting wires. In the state of rest, that is to say, when none of the two levers o are depressed, the wire a. b through one of the two coil wires m, and the resting contact of lever o in both stations is conducting connection with earth. When lever o of Station A is depressed, then owing to this the conducting connection of the coilwire m with earth is destroyed, and at the contrary it gets connected to the free pole of a battery E derived to earth. The current of this battery now forks off in two branches. One of the branchcurrents traverses spiral m of Station A, the wire a. b, the spiral m of Station B, and through the resting contact of the lever o over there to earth. The other branch traverses spiralwire n of Station A, and returns to the battery through resistance W. The spirals m and n and resistance w, now ought to be so arranged that the two currents passing through m and n exercise an equal and opposed magnetizing effect on the enclosed iron of the relay magnet, consequently entirely no magnetism in it is produced. In such a case the current proceeding from one Station will only magnetize the relaymagnet of the other Station.

This condition is sufficient in the established current scheme by making the products of the current strengths of both branchcurrents equal to each other in the number of turns of the Spirals m and n. As the currentstrengths in both branchlines stand in an inverse proportion to its resistances, on that account, consequently the number of turns of both Spirals must stand in the same proportion as ~~of~~ the total of resistances of the appurtenant circuit.

If this proportion is produced by a proper arrangement of resistance W, then no magnetism appears in the magnetcore of its own relay, hence A keeps its own entire susceptivity for the current arriving from the other Station.

As ~~an~~ additional condition for the equally assured simultaneous speaking we have to observe that the magnetizing effect of the current arriving from the other station ought to remain of the same size also in such a case when the contact lever is included in the motion. If E represents the electromotive force of the active battery, w the total sum of resistance of the mainline a.b, —

w' the resistance of the equilibriums wire, m and n the number of turns of the like-named Spirals, and if the resistance of the batteries as immaterial in comparison with the remaining resistances is slighted, then we obtain from the above the condition equation

$$\frac{m E}{w} = \frac{(m + n) E}{w + w'},$$

which equation likewise is sufficient, when we make $\frac{m}{n} = \frac{w}{w'}$, as is required for the equilibrium of the current progressing from the own battery.

In practical performances we have generally preferred to make the number of the turns of both Spirals, and consequently also the resistances of the main and equilibrium circuit equal to each other, although doing so the ~~use~~ consuming of ~~covered~~ spun brass wire for the relays, and spun germansilver wire for the equilibriums resistances increases. We did this, because greater resistances are easier to be equalised with a correctness quite sufficient for practical purposes, and the variable resistances of the contact-spots in this way are more out of the question, but mainly in order not to weaken unnecessarily and making inconstant the current of the battery passing through the wire by having a too short branchline. As namely very often in the Telegraphoffices are used inconstant batteries consisting of coalzinc chains filled up with diluted sulphuric acid, owing to that the electromotive force becomes decreased very rapidly through polarization, when their activity considerably comes in for. The arriving current hence will become very unsettled in short equilibrium lines then, when the wire is imperfectly isolated, and owing to that, the outgoing current is considerably increased. Likewise short branchlines of the battery have the disadvantage, when constant chains are used, that particularly much more powerful elements ought to be used when more apparatus ought to be worked by one battery. (1)

Note (1) Dr Stark in Vienna has described number 8 of the Journal of the German-Austrian Telegraph Union 1855 an improvement of our counterspeaking method, which consists that, different from the apparatus forwarded by us to Vienna, the proportion of the number of turns both branchlines are made by him not equal. The reasons why usually we have made the resistance and the number of the turns of both branchlines equal have been described by us heretofore. Dr Stark calculates that his magnet provided with an unequal number of turns owing to this has obtained a greater sensibility at the rate of 1 : 1.67. However he has neither taken in consideration that the resistance of the encircling wire, and consequently also that of the entire line, in admitting his opinion

The problem of Simultaneous Speaking in opposite direction on one and the same wire may be considered as fully solved through the described construction, as this is confirmed by a practical experience of several years.

However this proceeding is not applicable there, where the currents passing through the telegraphlines are not of constant strength, consequently ~~[illegible]~~ neither in long submarine nor underground lines, nor in cases where a greater number of magnet-spirals is intercalated in the line. In the first case the main spiral is predominant at the beginning of the current, in the second the equilibriumspirals, hence in both cases no complete equilibrium of both is to be obtained.

Halske and myself have obtained a not much better practical result in solving another problem, that of simultaneous

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is incurred, ~~[illegible]~~ nor that for a larger resistance a more appropriate proportion of diameter for the coilwire may be selected, and through it the advantage of the unequal number in turns calculated upon by him, can be compensated almost. An increase of resistance of the magnet spirals inserted in the line however is not advisable, because the auxiliary closings of the wire caused by imperfect isolation operate the more injurious, the larger resistances lay between them and the battery. We have

more

speaking with two apparatus in the same direction by means of Morse' writing apparatus.

If we so connect by means of appropriate mechanism, two batteries of different capacity with one end of a telegraphic line and earth, that, without breaking the continuity of the current, one or the other of the batteries or both together can be inserted, then we may produce three different current strengths in the line. If battery II be twice as powerful as battery I, then the current strengths caused by battery I. II and I + II will stand in the proportion of 1 to 2 to 3. If now at the other end of the line between

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made our first experiments in the direction of Dr Stark's improvement, and also afterwards made frequently counter speakers with smaller equilibrium resistances, but found it practical, that the equilibrium of the currents was to effect and to obtain the easiest, when both wires were wound simultaneously and with an equal number of turns.

The advantage is obtained by so proceeding, that in both line branches the wires of a differential Galvanoskop may be inserted, and with the aid of them easily the exact arrangement of the resistance of the equilibrium line may be effected.

the latter and earth two relays are inserted, of which one is put into activity through current strength 1, whilst the second only is brought to attraction by Current Strength 2, then the solving of the problem requires that relay I be brought into motion only by current strength 1 and Current Strength 3, — but not through current strength 2. This may be done in several

Double 1855

ways: First we tried in the beginning of the preceding year by means of a local battery to compensate Current Strength 2 on relay I. This was done by by winding two wires around the magnet of relay I, of which the one was intercalated in the mainline, whilst the other got traversed by a branchcurrent of the local battery, when relay II had attracted its armature. This local current was so regulated by a rheostat that it caused in relay I an equal and opposed magnetism as current 2. Hence, when battery II was intercalated in the line, relay I in fact was put momentarily in activity, but as soon as also relay II had attracted its armature the action of the equilibrium current set in, and the armature of the relay I again fell off, before the momentary closing of the local chain which was caused by it had been able to produce a signal on the paper slip. When however also battery I was inserted, then current strength 3 circulated into the line, — the equilibrium of the current in

relay 1 hence was interrupted, and the same attracted its armature by the action of the difference in currents, that is to say, current-strength 1. The result of this experiment was, as was easily anticipated, unsatisfactory.
Without mentioning the trouble to keep two currents produced by different batteries in a permanent equilibrium, we even could not obtain in our room a regular writing, mainly for the reason that the action of relay 1 became too slow, when the equilibrium spirals are closed through the local battery, and because relay 11 does not work steady alternately with currentstrength 2 and 3, as this ought to be. —

The Currentscheme for the described Solution of the problem of doublespeaking is represented in plate 11 fig 8. The spirals of the relays R_1 and R_2 are represented by S and S', the equilibriumspirals of the relay R' with S''. a and a' are the armatures of both relays, K and K' their contacts, through the contact of which with a and a' the current of the localbattery B through the wirespirals S and S' of the writing apparatus is brought forth. Further through contact a' K' an auxiliary closing of battery E_1 is effected through rheostat w and the second spiral S'' of the relay 1 throughout. Rheostat w is so arranged, that the Spirals S and S'' equalize at currentstrength 2, and

and exercise an opposite magnetizing effect on the iron core of the magnet, consequently get neutralized at this current strength.

In Currentscheme fig 9 on the contrary the spirals S" permanently are passed by a current of battery B, and well in the same direction as spiral S. If the line is crossed by currentstrength 1, then through the common action of both spirals the armature becomes attracted. If on the contrary at currentstrength 2 also the armature a is attracted, then the localcurrent ~~listens~~ lessens through S", and armature a falls off. Currentstrength 3 on the contrary attracts the same again.

With aid of a third relay R^3, which only with currentstrength 3 attracts its anchor, the untimely neutralization of currentstrength 2 in the relay R' can be removed through a local current. Fig 10 and fig 11 represent two such Currentschemes. The letters mean the same thing as we have said before. If it is taken in consideration that the strong lines are traversed by the line current, on the contrary the weaker ones by the local currents, then these courses of current also without any special description will be fully intelligible.

We want to remark further, that in Scheme fig 10 the action of currentstrength 2 gets compensated in the double wound magnet of the writing apparatus, whilst in the scheme fig 11 this compensation in relay R' takes place by the line current itself, as the current is compelled to run through both equal spirals of relay R' in opposite direction, when armature a' is attracted, and so is contact with its rest contact or is raised.

A great many similar currentlines can very easily be combined, through which the problem of doublespeaking with more or less good result is solved. We however have not been successful on one of these ways to get at a practical useful result. This may be also be explained by the fact that in doublespeaking three different current strengths have to be utilized and regulated, in order to get at the telegraphed signals of both apparatus properly divided, whilst in counterspeaking there is only question of two current strengths. Doublespeaking hence seems to have only little prospect of further development. (1)

Note (1) Dr Stark has in Book 10 year 11 of the Journal of the German Austrian Telegraph Union suggested two projects for double-speaking, of which one is almost in conformity with that which we have described at first. The other with relays is at the least not more appropriate than that which we have experimented ourselves. Although we have up to the present time

For the sake of completeness I will cite still another experiment, which Halske and I made, in order to get at the manifold simultaneous use of one wire

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not yet published our experiments as we want them previously have carried through entirely, still we have in the course of the preceding year very frequently made oral and written communications about it to every one who felt interested in it. In August of the preceding year amongst others I communicated to Prof Pouillet in Paris some current schemes to be taken up in a recently published work.

At the end of his treatise Dr. Stark makes an erroneous statement, which ought not to be remain unnoticed, because it shows, that also he shares the opinion of Dr Gintl, that electrical currents penetrate each other, almost, without interrupting each other! He holds namely the opinion that counterspeaking can be combined with the double speaking described by him, so that consequently with four telegraphs simultaneously can be telegraphed along the same wire. Counterspeaking just as doublespeaking through the same wire and with Morse's writing apparatus, or in general such telegraphs, which require currents of different duration in order to give a signal, is only possible by changing the currentstrength in the line. Counter & doublespeaking in the way described till now, necessarily must interfere with each other, — hence is not possible at the same time. —

Criticism of Starks idea of quadruplex.

in a quite different way.

When one causes currents of the same force and duration and varying direction, as are produced in the spirals of an iron armature, which rotates in front of the pole of a powerful magnet, - to pass in rapid succession through the spirals of an electromagnet, then there is no magnetism produced in its iron core. An electro-dynamitic relay simultaneously crossed by these currents (for instance a Weber's electrodynamometer with contact-arrangement) however may be put in motion through it. The electromagnet will on the contrary get into activity through a weak contact current, which we allow to pass alone or simultaneously with the varying current through the same spirals, whereas the dynamical relay which needs more powerful currents, does not get affected by it. Hence in this way, when the oscillating currents posses an adequate strength, doublespeaking may be done with perfect certainty. As the counterspeaking proceeding hereabove described can be done as well with oscillating as by simple currents, the sort is likewise possible through this to perform double and counterspeaking at the same time.

This method is just as little fit for practical use. The applying of such powerful currents as are required for an elektrodynamitical relay is in general unsuitable. Especially

Such rapidly changing currents as are needed in order to make the electro magnetic relay perfectly inactive, cannot be made use of, as they can not be transmitted on great distances. In submarine or underground lines this phenomenon hardly needs any arguming. The electrostatic charge, which I have first described in this work afterwards more extensively and especially corroborated by Faraday's investigation, consumes short alternate current entirely. If the change of currents is considerably more rapid than the charge time for the entire wire, then in fact positive and negative charge-waves will move on in the wire the one after the other, but in progressing must flow in each other, and hence lose very rapidly in intensity. As I will explain in a separate treatise about the charge phenomena afterwards, the overground lines must be considered as large Leyden Jars, be they of far smaller capacity as underground lines of the same dimensions, where the air between wire and earth stands for the glass of the jar. The charge of land wires resulting from this as well as their even imperfect isolation, and the therewith connected polarisation of the wire varying with the direction of the current and of the plates which form the connection with earth effect a weakening of them, which increases rapidly the farther they are removed from the source of the alternating currents.