

(What is meant by "placing the beam under the influence of an electric or magnetic field and directing it onto the screen" is merely that the electron gun is aimed at a target ~~is accomplished~~ by applying voltages to the members of two pairs of deflecting plates located within the tube, which plates act upon the beam.
Invention of an Electronic Cryptograph

1. The basic instrumentality in this invention is an ~~modified~~ electron gun ~~electron gun~~ of a type ~~is~~ similar to that used in the cathode-ray tube of a ^{modern} oscillograph.

2. In the latter type of tube the electron stream is concentrated into a beam, which beam is placed under the influence of an electric (or magnetic) field and then directed onto a specially prepared screen located within the tube. This screen fluoresces at the point of impact of the electron beam and thus makes visible the trace of the beam.

3. Let the electron beam, instead of being aimed at a non-conducting target bearing or supporting a set of a fluorescent screen, be aimed at a ^{set of} small metal disks; and each of these disks be connected to a terminal outside the tube; and each of these terminals be made a separate electrical circuit outside the tube by means of a conductor passing through the glass wall.

Then instead of producing a fluorescence on a screen the electron stream will produce ~~traces~~ ~~of~~ ~~currents~~ ^{in the circuits in} which the metal disks being ^{located} bombarded. These circuits ~~the disks struck~~ by the electron beam is located may then directly operate relays, or other electrically-responsive devices; or they may be amplified first and then ~~be~~ used to control ~~a~~ relays or other devices.

4. The ~~aiming~~ ~~of~~ ~~the~~ ~~electron~~ ~~gun~~ ~~is~~ ~~accomplished~~ by means of ~~two~~ pairs of ~~deflecting~~ plates known as the horizontal and the vertical deflecting plates, the electron beam can be made to describe various figures, simple or ^{complex}.

complicated. If the ~~impressed~~ ^{impressed} voltages impressed upon the deflecting plates are of a constant character (d.c.) then the stream of electrons may be directed against a specific

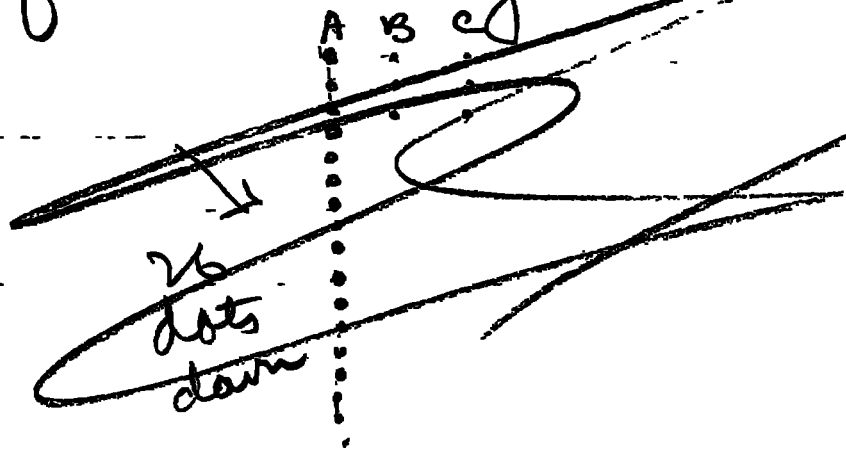
4. The Cathode-ray tube of the ~~other~~ type just described has recently been invented by personnel of the International Business Machines Corporation and patents are pending on it. This tube ^{itself} forms no part of the present invention, which is concerned with circuits and arrangements for making combinations of such tubes serve cryptographic purposes. In other words, the object of the invention is to construct an ~~fully~~ electronic cryptographic machine with as few moving parts as possible.

5. Suppose the ^{conducting disks on the} target be ~~be~~ arranged upon the coordinate system, ~~with~~ in a square 26 x 26, or 676 disks in all. Each disk is connected to a terminal outside the tube. Now suppose that a series of 26 different voltages are available and can be ^{voltages} impressed upon the vertical deflecting plates, ^{these voltages then can be made to} correspond to the ~~the~~ letters of the plain text to be enciphered; suppose that ^{another and} a similar series of 26 different

voltages are available and can be impressed upon the horizontal deflecting plates, these voltages then can be made to correspond to the letters of the ~~key~~ enciphering key. Encipherment by such a scheme will thus correspond to ^{encipherment by means of} ~~the use of~~ a quadrangular cipher table, the cipher equivalent of a given plain-text letter depending upon the key letter employed in its encipherment.

b. Means for impressing the various ~~different~~ voltages on the vertical deflecting plates (to correspond with the plain-text letters to be enciphered) are readily available. A potentiometer can be arranged to accomplish this function, so that, for example, when the key A is depressed on the keyboard, ^{the 'electron beam' comes under the influence of a} ~~a voltage of constant potential of 1 volt~~ ^{is impressed} ~~cause the beam to be~~ ^{the electron beam is} directed into the 1st row of ~~the~~ disks on the target; when the key B is depressed, the beam is directed into the 2nd row, and so on. Thus the 26 voltages may be used to direct the beam at the 26 rows of elements in a Vigenere square. ~~The elements in this case~~ of conducting disks carried by the target inside the cathode ray tube. These then correspond to the 26 rows of letters in an ordinary quadrangular cipher table. ~~These are three of 26 rows of disks, corresponding to the 26 rows of letters in a Vigenere square.~~

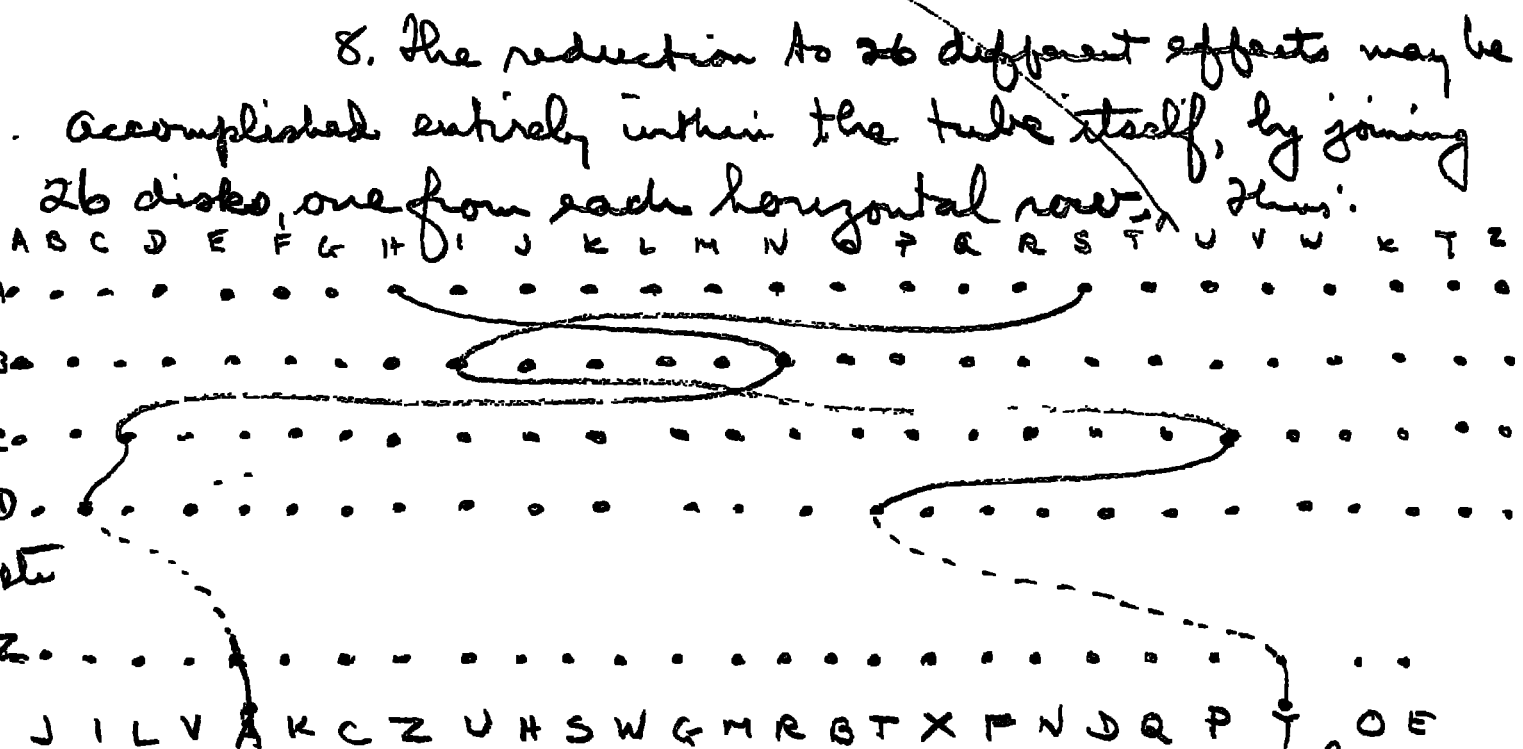
7. Means for impressing the various voltages on the horizontal deflecting plates (to correspond with the successive key letters entering into the ciphering equations) are now to be ~~discussed~~ discussed. It is obvious that if only one voltage were applied to the horizontal deflecting plates the result would be monoalphabetic encipherment. It ~~is also obvious~~ ^{follows therefore} that for polyalphabetic encipherment means must be provided for successively varying the ~~at volt~~ keying voltages impressed upon the horizontal deflecting plates, so that ~~successive~~ ^{successive} encipherments of even the same letter will yield different cipher equivalents, as the keying voltages change. ~~This corresponds to selecting the various columns of a Vigenere square according as the key letters change.~~



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Thus these 26 voltages may be applied to the beam at the 26 columns of conducting disks carried by the target inside the cathode ray tube. These then correspond to the 26 columns of letters in the quadrangular table. Thus, a coordinate system of finding cipher equivalents has been established and

A potentiometer can also be arranged to accomplish this function, so that, for example, when the letter A is the key letter, the electron beam is directed onto the 1st column of disks on the target; when B is the key letter, the beam is directed onto the 2d column, and so on. ~~But this~~ It is seen that by regulating the voltages impressed upon both the horizontal and the vertical deflecting plates, ^{simultaneously,} to correspond with plain-text / key letter relationships, encipherment ~~corresponds to~~ by the usual quadrangular cipher table method can be accomplished ~~instantaneously~~ by means of the tube ~~as~~ described. If ~~but this~~ ^{simple, preferably electronic} means for changing the successive key letters has been devised. This will now be done. means are incorporated to change the key letter with each encipherment, according to some aperiodic sequence, then a fairly secure method will have been established for cryptographic purposes. It is to be understood, of course, that the 676 disks are connected to but 26 different final terminals, so that only 26 different resultant effects are obtained from the aiming of the electron gun at the target. This obviously corresponds to the final effects of a quadrangular table, which are reduced to but 26 different effects.

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 to one terminal outside the tube.

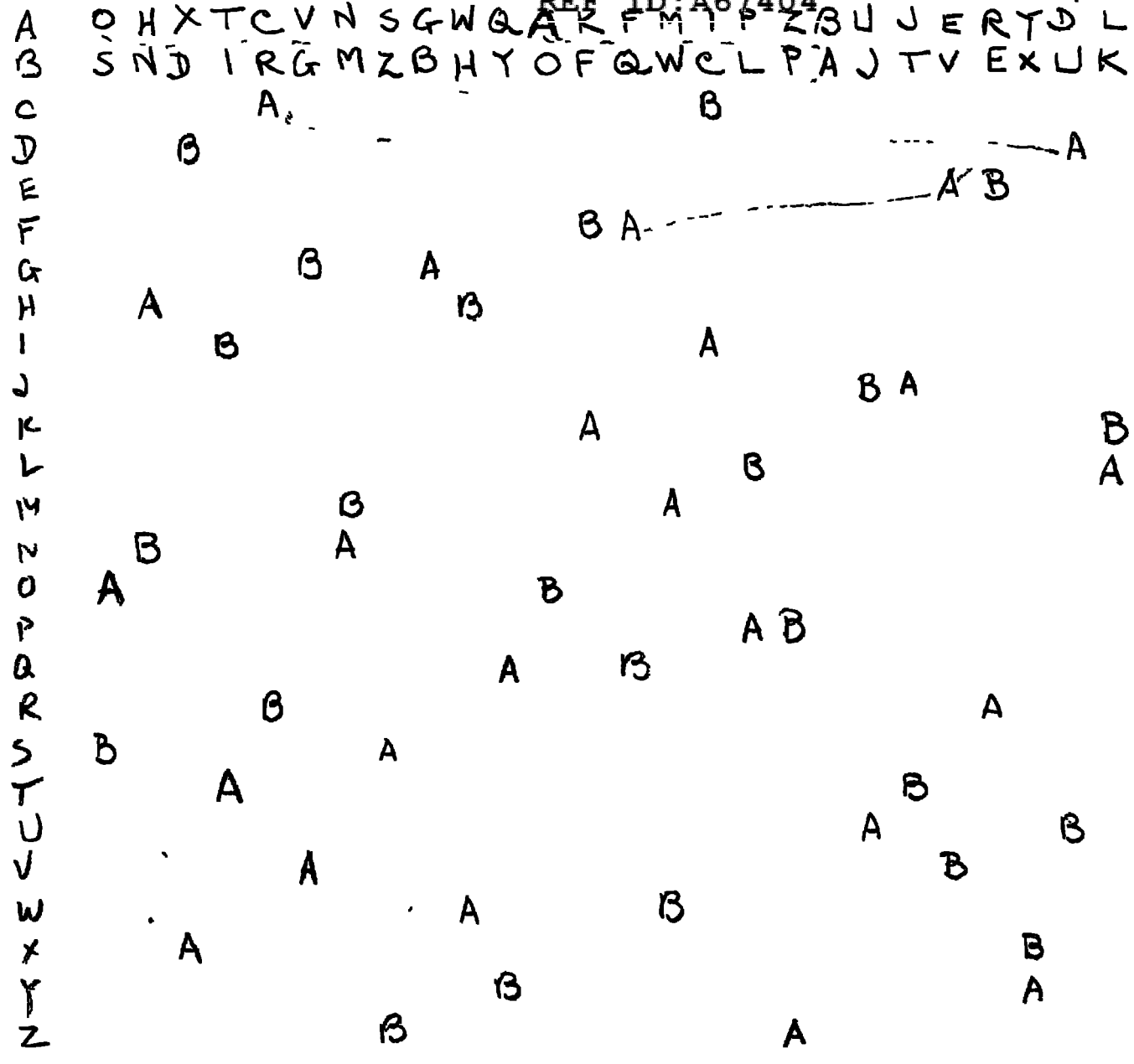


In this sketch A_p enciphered by H_k , ~~A_p by B_k~~ , B_p by C_k , C_p by C_k , D_p by B_k , and Z_p by E_k all yield A_c . A_p by S_k , B_p by I_k , C_p by U_k , D_p by O_k , Z_p by $X_k = Y_c$.

9. If this is the case, then once a tube has been wired up, no changes are possible so far as concerns the exact cipher equivalent obtained for each specific encipherment. But if the ⁶⁷⁶ individual disks were connected to ⁶⁷⁶ individual terminals outside the tube, then the cipher resultants could be changed at will, by suitable ~~flexible~~ switchboard arrangements.

10. By arranging the wirings for reciprocity, the same tube can be employed ^{for both} for enciphering and deciphering. An illustration follows.

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
 O H X T C V N S G W Q A K F M I P Z B U J E R Y D L
 S N J I R G M Z B H Y O F Q W C L P A J T V E X U K

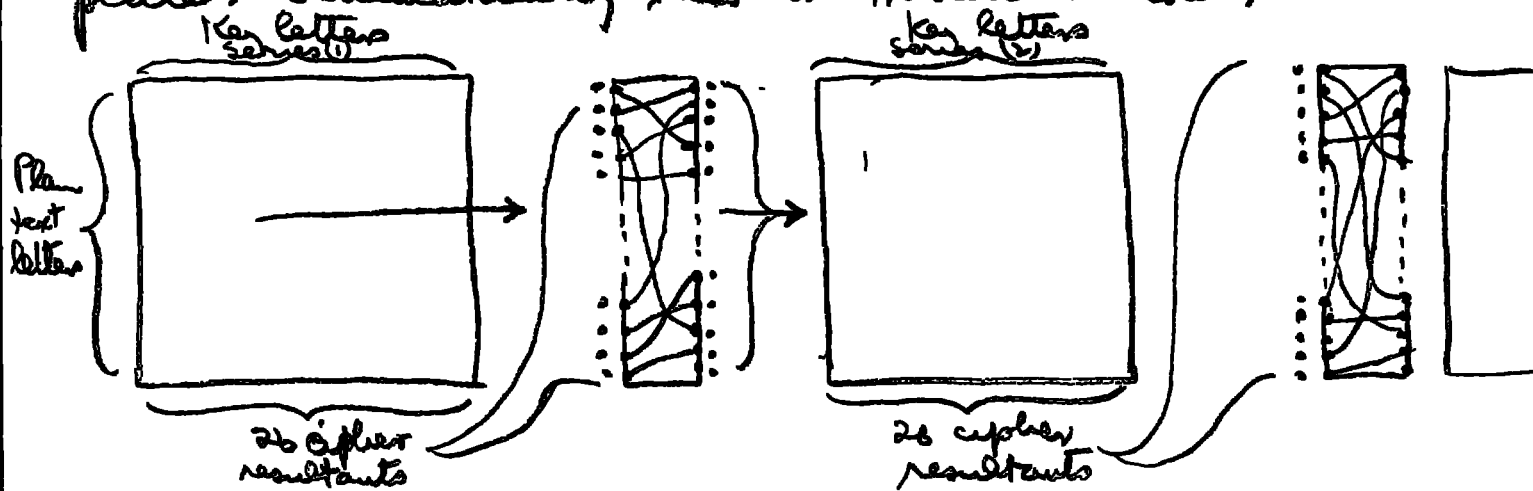


$$\begin{cases} A_p(A_p) = 0 \\ 0_p(A_k) = A \end{cases}$$

$$\begin{cases} B_p(L_k) = 0 \\ 0_p(L_p) = B \end{cases}$$

$$\begin{cases} A_p(B_k) = H_c \\ H_p(B_k) = A_c \end{cases}$$

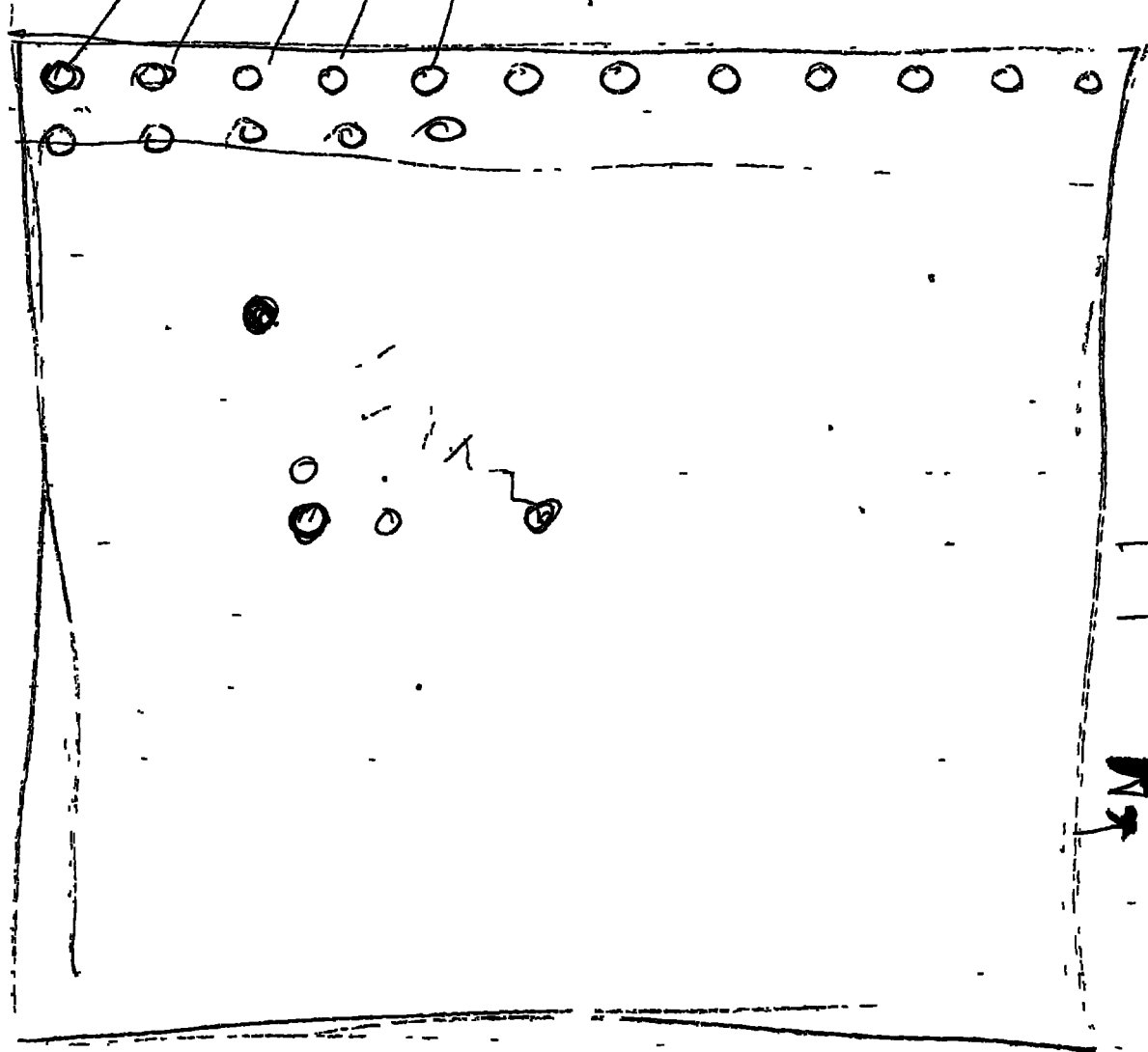
11. The 26 different results coming out of one tube may be led to a second tube via a connection changer plate. Schematically this is shown below:



12. By continuing this arrangement a "cascade effect" may be obtained, analogous to that obtained by juxtaposing rotatable cipher commutators.

a/

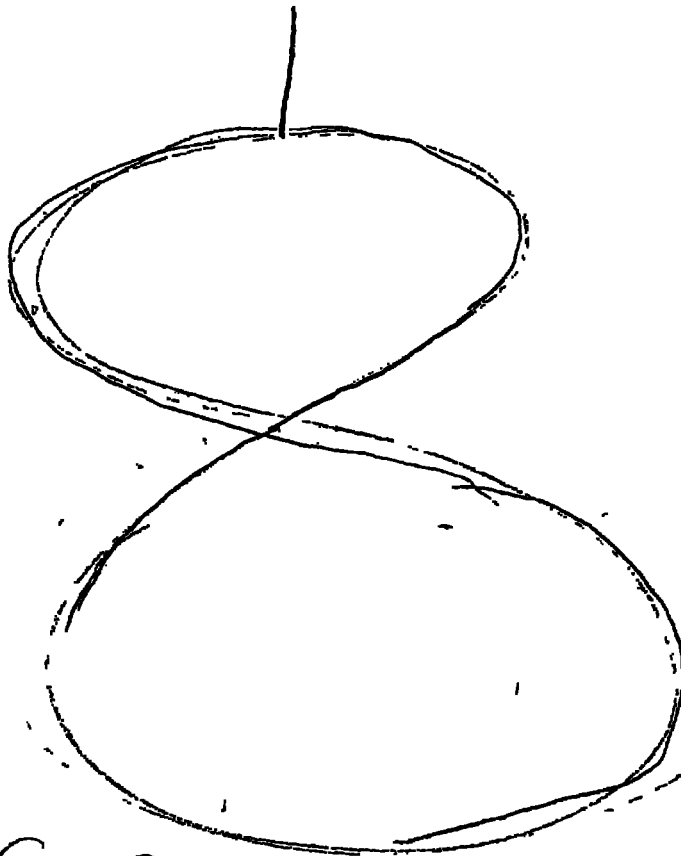
R



P.R.M



26



Handwritten signature or scribble, possibly reading 'L. S. C. W. W. W.' or similar, written in a cursive style.