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The Production and Detection of Messages in Concealed Writing and Images

Publication No. 50

RIVERBANK LABORATORIES
DEPARTMENT OF CIPHERS
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by
H. O. Nolan

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PART I

THE GENERAL EXAMINATION OF DOCUMENTS SUSPECTED OF BEARING CONCEALED WRITING OR IMAGES

It may seem illogical to deal with the detection of concealed messages before treating of their preparation. There are, however, sound reasons for adopting this order. In the first place, the detection of concealed messages is very much the more important of the two processes from the intelligence point of view. Secondly, without a good knowledge of the methods that may be applied for the detection of concealed writing and images, it is not possible to set about, in an efficient manner, the preparation of such messages. Thirdly, the detection of concealed messages is work of a more general character than their preparation.

This last remark requires, perhaps, some explanation. What is meant by it is that the detector of a concealed message is not so much interested in knowing the process by which it has been produced, as in ascertaining into which of a few general classes it can be placed by the use of his reagents. He possesses indeed, two agents before which the vast majority of secret inks will fail. These are: first, heat; second, treatment with Silver Nitrate and exposure to light.

Consideration of the nature of the two functions will show that the search for and detection of concealed writing is the one which calls for the less knowledge. The searcher for a new process for concealing a message must acquaint himself with all the methods employed for the examination of suspected documents, as well as with the chemical and physical phenomena of which he may avail himself for the elaboration of new methods. The examiner, on the other hand, is, strictly speaking, sufficiently well equipped, having possession only of the former knowledge, with a certain amount of skill and considerable sagacity.

This being so, the examination of these documents is a more elementary or lower branch of the subject and, fitly, is treated first. It is evident, however, that there must be frequent cross references.

In Part I, therefore, will be treated the subject of the *general* examination of suspect documents. The special examination of documents requiring such will be dealt with under specific processes in Part II.

In what follows, I am treating the subject of the examination of a suspect document in the same way as the general examination for poisons is treated in works on toxicology, that is to say, I am assuming what can scarcely ever be true, that the whole process will be gone through in practice. Even in the most elaborate case, a number of short cuts will be used and, in some instances, only a few of the tests mentioned will need to be applied.

Care in handling. On receiving a suspect document, one must bear in mind that it may be seriously damaged if it is handled too much. Every one concerned with work of this kind knows, or should know, that every touch, except of the driest hand, leaves a detectable image of a finger print. This image may come up in the course of your investigation, and may mislead you or obscure your results.

In certain other lines of work, where it was necessary to determine whether letters had been opened between the time of their mailing and their receipt by the addressee, the present writer resorted to the plan of using sensitized paper in non-actinic envelopes, placing the letter in the envelope in the dark room. The letter and envelope were also opened by the addressee in the dark room, and treated with a suitable developer. It is evident that this method might be employed for the purpose of conveying secret information, and this possibility must therefore be borne in mind. In one respect it would be an unsatisfactory process, because it would sin against the principle that the paper should not be in any way suspicious. It is perhaps, however, worth while, when circumstances permit of it, to open suspect letters by red light. If neither the paper nor the envelope lining is of a character to protect a sensitive surface from the light, the possibility of this method of having been employed may be excluded; in the contrary event, the indications are obvious.

PRELIMINARY EXAMINATION

Examine all parts. It should be unnecessary to mention that all parts of the envelope, including the space under the stamp, should be examined with as much care as the rest of the paper. In many cases it may be necessary to forward the document on its further journey without its bearing evidence of your having tampered with it. It may, indeed, arise that a facsimile of the original document must be prepared, with a misleading message concealed in it by the method employed by the original correspondent. With this in mind, a very careful preliminary examination of the document is carried out.

Dimensions and shape. The dimensions are carefully measured. A departure from those of the standard sizes is an indication that the paper has been cut down. The differences in the standard sizes in different countries must not be forgotten and, in particular, it must be remembered that Canadian practice tends to follow the English size. Also in writing pads there is less exact adherence to standard sizes than in separate sheets. In this case, however, there should be, along one edge, indications of the sheet having belonged to a pad.

The dimensions will also give us the shape of the paper, provided one of the diagonals is taken. It is easier, however, to treat the shape as a separate quality. It is well known that paper cutting machines produce remarkable accuracy in squareness, and any notable deviation in this respect should attract attention.

Quality of the paper. The investigator should be supplied with books of paper samples, classified in such a way that inspection will enable him to determine what kind of paper he is dealing with. The importance of this point is chiefly in connection with variations from the normal, indicating special treatment. Thus, if the paper is judged to be an ordinary quality of writing paper and yet has the stiffness and crackle of a bank note, we may be certain that it has been re-sized, probably with gelatin (see Part II, Compound Methods).

Surface. In examining the surface of the paper, it should be held so that light falls on it very obliquely, and it is advisable to provide yourself with a simple piece of apparatus arranged so that the paper can be illuminated with glancing light only and examined against the light, with the light, or, in two opposite directions, at right angles to the light. This will reveal any suspicious disturbance of the surface and, occasionally, will even enable one to read the concealed message or part of it. The same operation should be repeated after gently breathing on the paper, in order to produce the maximum hygroscopic condition without actually dampening the surface. If the paper is ruled or carries any printed matter, engraving, or embossing, the condition of these must be very carefully examined, as they may show traces of the manipulation to which the paper has been subjected. The embossed work may be softened or may, when examined with some magnification, show a broken surface coat. All that the printed or engraved matter is likely to show is a slight veil due to the deposit on it of some substance suspended in the extra size.

Weight. The paper should now be weighed and its weight compared with the known weight of a sheet of similar dimensions and of the same kind.

Translucency. The next point to take up is the transparency or translucency. This is best judged of by placing the paper between two sheets of glass, in a photographic printing frame, and holding it up to the light in such a way that the eye sees no other light except that passing through the paper. Opportunity should be taken at this time to observe any water mark and to note whether the paper is "laid or wove" and, if the former, to measure the separation of the wire marks and note any irregularity presented by them.

Photography. A photograph must now be made, of the exact dimensions of the original. This is not the place to state how to overcome, by contrast filters and special plates, the difficulties of photographing blue and violet inks. One photograph should be made for the purpose of executing a facsimile of the document if this should prove necessary. Another should be made of a totally different character: it should be as "photographic" in its qualities as it is possible to make it, that is to say, that all the peculiarities of the photographic plate should be taken advantage of to detect slight local changes in the paper. This latter photograph should, therefore, be taken on a slow, ordinary plate, preferably by the light of a mercury vacuum lamp, with a quartz rather than a glass tube. In this way, ultra-violet rays get full play. Contact prints of the document from one or from both sides, according to circumstances, should also be made with slight under-exposure. These are of some assistance in detecting local peculiarities.

Finally, it is highly to be recommended that a contact print on bromide paper with the x-ray be taken, giving the minimum exposure which will just distinctly fog the bromide paper. This will serve to detect certain methods of concealed writing employing a chemical substance, one of whose constituents is of high atomic weight, and therefore of considerable opacity to the x-ray.

Although the examination of a document by x-rays will occasionally be useful in revealing the presence of an element of high atomic weight, it has not been found practical to depend on this as a means of communication. The present writer, some years ago, prepared a number of "compound inks," based on this method. Although success attended these attempts, it was found that the method required a too delicate adjustment of conditions, both at the receiving and at the sending end, for the process to become practicable for purposes of secret writing. It is possible however, that conditions more closely approximating a standard could be established by incorporating a compound of a heavy metal (such as Mercuric or Lead Sulphide), in printers' ink, or in the ink on a typewriter ribbon. There would still remain the difficulty at the receiving end, which difficulty arises from the necessity of having an exceedingly hard tube and a very short exposure. On the other hand, the operations do no injury to the document and can, therefore, be repeated until a satisfactory result is obtained. It is evident that this method, in common with all others of a complex character, is only adapted for communications of the greatest importance which can be prepared at leisure.

This completes the preliminary examination, and from it some information may very probably have been obtained as to the direction of our subsequent researches.

THE PAPER

Body. As they affect our subject, the different qualities or bodies of paper are of little importance. Speaking generally, the better the quality of the paper, that is, the nearer it approaches to the well beaten, well sized rag, the better it will serve the purpose of concealed writing. The reason of this is that the poorer qualities of paper, whether mechanical wood pulp, chemical wood pulp, esparto, or other, are wanting in uniformity and, not infrequently, contain irregularly distributed particles of a nature to interfere with the secrecy of the writing. If, for any reason, it is necessary to write on such a paper, as may be the case when secret communications are being sent on printed matter, the most searching investigation and trial must be made to satisfy one's self that the writing method to be used is adapted to the paper, using the criteria laid down in Part II.

Size. Passing from the body, we come next to the sizing of the paper. This plays a much more important role. The size may be composed of gelatin (glue) with alum; rosin; casein. With these may be incorporated fillers such as Barium Sulphate or Kaolin (china clay). When there is a choice, the writer will use a gelatin-sized paper; firstly, because its conduct is more uniform and secondly, because gelatin sizing is only used on papers of good quality.

It is of no use to lay down a rule as to what papers may be used for what purposes. There is one general principle which governs all this matter, and that is that you must try out your method on the paper which you are going to use. You cannot safely transfer the results of experiments, made with a given "ink" on one kind of paper, to another kind without trial.

Unsized paper (blotting paper, filter paper) is unutilizable for simple methods, because the difference between the written and the unwritten parts of the paper would be immediately detected in the routine examination. Unsized paper, however, can be very useful in compound methods, where it is desired to make certain for one's self of the nature of the sizing.

It sometimes happens that it is desired to make an imitation water mark (see Part II). For this latter purpose, wove filter paper of fair quality should be used. The "wove" appearance due to the wire cloth, can be, in part, obliterated by pressure and, in part, concealed by a suitable filler. Usually, however, there is no objection to this being visible.

The making of paper of fair quality is by no means difficult, and if your water mark message is likely to pass under the scrutiny of a really competent expert, it is better to have recourse to home-made paper. For instructions on this subject, see Part II.

For definitions of simple and of compound methods, see Part II.

THE INK

We have already adverted to the possibility of incorporating in the ink a "dense" constituent, detectable by the x-ray. This method is, however, for reasons we have given, not easily practicable. Nevertheless, great vigilance must be exercised to prevent the passing of secret communications by modification of the ink of the "open" writing. For some of the methods which may be used, see Part II. The processes there described are by no means the only ones available. An almost infinite variety can be devised. Therefore, no part of a suspect document requires more careful examination than the "open writing."

CHEMICAL EXAMINATION

Unless some help has been afforded by these examinations, we are now face to face with a very difficult proposition. In the first place, we do not know in what part of the document the writing, if such there be, exists. An important message may easily be conveyed in a space of 2 inches by 1 inch, a space such as would ordinarily be occupied by two applications of reagents. It may be that these two reagents, while failing to reveal the message, will suffice to destroy it, and our subsequent work will be thrown away. This, however, is in the nature of things, and it is the fortune of war.

Reagents. Let us first pass in review the reagents and agents which we may have to apply to a document. The following list, though not exhaustive, covers the majority of these. Those in the first group may be classed as general reagents, those in the second group as routine reagents. Those in the third group are the most commonly used special reagents.

I. Jeweler's rouge.
Heat to singeing (hot iron).
Solution of Silver Nitrate.

II. Solution of an alkaline sulphide.
Solution of Ferric Chloride, with some Ferrous Sulphate.
Solution of Ferrocyanide of Potassium.

III. Alcohol solution of Methyl Red (.2%).
Solution of Sodium Alizarin Sulphonate.
A basic dye of the triphenylmethane series.
Schiff's reagent (rosaniline-sulphurous acid).
An alkali.
Mercuric Bromide-Metol physical developer.
Pancreatin.
Dimethylglyoxime in alcohol-ammonia.
Lugol's solution.
Bromine.
Nitric acid.

APPLICATION OF REAGENTS

The order in which the various agents are applied to the places suspected to carry concealed messages is determined, generally speaking, by the consideration that it is preferable to use first those agents which do not fatally interfere with the subsequent use of others. This rule, however, is more honored in the breach than in the observance, except among the agents of the general group. It is not practicable to apply every known agent nor even every one of those in the limited list that has been given. Before, therefore, commencing the use of reagents in the routine manner, serious consideration must be given to what has been learned, negatively and positively, in the preliminary examination, and an attempt must be made to plan out your short cuts. The examiner will probably have information as to the personality of the supposed writer of the document, as to his relations, and as to the possibility of his using the more difficult of the compound methods. If he does not possess this information, then the blame, if blame there be, falls not on him, but on the Information Branch of the Intelligence Department. It is a great deal more difficult to examine a document for all possible kinds of concealed messages than it is to examine a small quantity of human viscera for all known poisons. Yet, though schemes have been drawn up for the latter purpose, it is notorious that in practice they are utterly inapplicable. We will content ourselves therefore with the statement of the how and why of the principal tests used, leaving it to the examiner to choose among these tests, basing his choice on the information furnished him from outside and from his preliminary examinations.

1. ***Jewelers' rouge.*** The use of this powder is to detect greasy or tacky places. Being composed of an ignited ferric oxide, it is a substance which does not react chemically with any ease and does not, therefore, interfere with subsequent examinations except so far as it hides slight reactions. This will only occur, however, where it has stuck to the paper because of greasiness or tackiness. There are two cases in which this is particularly likely to occur.

1. The rouge will pick out the characters of an open message where these have been made with a greasy ink or covered with a greasy film. (See Part II.)

2. Over finger marks. These, though sometimes of cardinal importance in another connection, do not interest us at present.

In the first case, you will be in presence of an open message and you will, as your first step in the examination, apply the rouge to test whether the ink with which the message is written, was greasy or not. If you find a considerable number of characters to which the rouge does not adhere, you will apply this agent over the whole of the document, dusting off the excess with a feather. You will then mark on one of your photographic copies the letters which have been picked up the rouge and the manner in which they have done so. It may happen that instead of the letters of the open writing differentiating in this way, other letters or signs may become visible. This would be the case if an unpigmented typewriter ribbon or ("grease paper") has been used on the blank parts of the paper. This method is not described in Part II because it cannot be regarded as a serious one. Not only would it be detected by the rouge, but also by heat and by silver nitrate.

Heat. Suspected portions of the paper should now be subject to singeing heat, best applied by a fairly hot iron. If the iron is clean and polished, there is no harm in applying it direct to the face of the paper, but if desired, a sheet of tissue paper may be interposed. The singeing should be to a tawny brown. *It is important that this color should be rapidly reached,* because in this way certain of the more volatile inks will be detected.

Silver Nitrate. This should be used in a solution of not less than two per cent strength in water and for most cases a solution of five per cent is better. It is better not to apply this reagent with a camel hair brush, but with a fine pipette. Some workers lay a portion of the document to be examined on a sloping surface and let the reagent flow down. I think it better to place the paper on a horizontal sheet of glass, to drop the reagent on it from the pipette, leading it over the surface with a point of the latter, and removing the excess by sucking it up with filter paper, and not by dabbing. The paper should now be allowed to dry spontaneously and should then be exposed to sunlight or to some other source of intense actinity. *During the whole of this exposure the specimen must be kept under continued observation.* If it is necessary to fix the writing, this may be done in the usual way with thiosulphate of sodium, or even by thorough washing in plain water.

Alkaline sulphide. This is used to detect heavy metals with black or colored sulphides (Mercury, Lead, Bismuth, Tin, Iron, Cobalt, Nickel, etc.).

In the crude, simple inks, this reagent plays an important role, but any simple writing with a metallic solution which will give a positive reading with an alkaline sulphide will be betrayed by the silver nitrate test.

For us, the alkaline sulphide solution has for its principle function the detection of heavy metal ink in compound methods. Of this there are two kinds. In one, the writing is executed in a dilute solution of a metal whose sulphide is resistent to solvents (e. g. Mercury), and the paper is then soaked in the solution of a salt of a metal whose sulphide, while resembling the first, is more soluble. Such a method is not really serious; first, because it violates the important principle that the document should not give rise to suspicion on being examined in the routine way, and second, because it is quite difficult to adjust the writing and the concealing fluids so that the former will not betray itself.

The second class of concealed message, the detection of which is effected in part by the use of an alkaline sulphide, is that class of writing where the heavy metal or metals is or are introduced into the ink of the open writing (see Part II).

The alkaline sulphide will be either a one per cent solution of Sodium Sulphide or a dilute solution of Ammonium Sulphide. It is applied in the same way as the Silver Nitrate solution but, while the reagent is being applied, the writing should be under observation with a lens magnifying from five to ten diameters. Should the application of the sulphide produce a change in the appearance of the writing different from that which ought to result with ordinary writing, then one must suspect a message by a modification of the ink and act accordingly.

The solution of Ferric Chloride (with some Ferrous Sulphate) should contain about one per cent of the former in water. It serves generally to detect ferrocyanides and thiocyanates used whether as simple inks or as modifications of writing or typewriting ink.

Solution of Potassium Ferrocyanide. This is the converse of the immediately preceding solution, and will rarely be used, because all that it can do will already have been done by the sulphide, and the ferrocyanide can only serve to identify the heavy metal.

PART II

METHODS FOR PREPARING MESSAGES

The methods for preparing messages fall into two main classes:

A. Simple

B. Compound

A—By a simple method is meant one in which the whole preparation of the writing on the paper is done in one operation. The "ink" used may involve elaborate preparation or, again, the development of the message may be complex, but so long as there is only one operation to be performed on the paper, the method is classed as simple; thus, writing on paper with Cobalt Nitrate is a simple method.

B—A process is classed as compound if more than one operation is performed on the paper in the preparation of the message. The majority of modern methods must necessarily fall in this class. For example, the numerous processes founded on photo-chemical reactions fall here, because they require several operations, which may be (for instance), impregnation of the paper, writing, exposure, fixing, washing.

It is a cardinal principle, which must be kept ever before the mind, that it is almost as important to prevent a message being detected or suspected as such, as to make it difficult to decipher. Many methods, otherwise utilizable, must be rejected because they sin against this rule. Writing made by them may be extremely difficult to decipher, but its presence is revealed by various indications. In military, or other wartime correspondence, what really matters is not so much to know the nature of a secret communication, as to make sure that its author is attempting to correspond illicitly.

SIMPLE PROCESSES

It is evident that the simpler the process, in the ordinary sense of the word, the more practicable it is at the *sending end*, the only one worth considering from this point of view. Unfortunately, however, the majority of "simple" processes, in the technical sense of the expression, produce a writing which is easily detected.

Practically all the methods described in books are simple, both in the technical and in the common sense of the term, but they are useless, except for such purposes as those of lovelorn lads and lassies, and for others where no close expert supervision is exercised.

Familiar instances are "inks" composed of a soluble ferrocyanide, of Cobalt Nitrate, of milk or other albuminous fluid, of saliva, of urine, of Lead Acetate solution, and so on.

For serious purposes these methods are in the discard; first, because they are well known; second, because each of them, in addition to having its own developer, is detectable by one or both of the two great enemies of concealed writing—heating, and treatment with silver nitrate followed by exposure to light (Part I).

Nevertheless, there do remain a few methods of the simple class which are still available. This is the proper place to remark that a method, once published, cannot be considered as a means of communication for serious purposes, such as diplomatic and military correspondence. In fact, every person desirous of communicating in this manner, should use, as far as possible, methods invented by himself or by his correspondent. It is, of course, evident that a method may be original with you and yet may be known to others and, in particular, to the censors.

From the considerations which precede, it is evident that indications for working out such methods will be more valuable than the description of concrete examples.

For the discovery of a new process of this kind, a fairly extensive acquaintance with chemistry is necessary and, in particular, the worker must have a good knowledge of analytical chemistry, organic and inorganic, while knowledge of colloidal chemistry and biochemistry will also provide a considerable reservoir of facts upon which to draw. Premising a basis of such knowledge, the worker will direct his search along two main lines:

First, he will search his knowledge and his literature for exquisitely sensitive chemical reactions, in which an infinitesimal amount of one of the reacting substances can be detected when placed on paper.

Secondly, he will search for specially rare reactions.

Sometimes he will be fortunate enough to discover a reaction which falls under both these heads.

It is evident that he must take into consideration theoretically, and test practically, the effect of the substance that he is using upon the paper, and also the permanence and certainty of its reactivity. Some substances, permanent enough in bottles or in tubes, and possessing very delicate qualitive reactions cannot be used in simple solution or suspension to write with, because they diffuse immediately in the substance of the paper; or, again, such a substance may be deliquescent. On the other hand, it is not true, as has sometimes been stated, that extremely soluble substances are to be avoided, because they would flow on the application of reagents. There is nearly always some way of applying the proper reagent so that the great solubility of the writing does not interfere with its development. Again, some of these inks will develop in a satisfactory manner only when exposed to some specific vapor, and will flow and disappear completely if tested with fluid reagents. It would be difficult to imagine a more suitable ink than one composed of such a substance as I have just described.

In every case, the proposed ink, in the concentration used or, better, a little more concentrated, must give a negative result with all routine methods of detection (see Part I). For most cases, chemical knowledge will suffice to answer the question as to whether the proposed ink satisfies the stated requirement. But, in respect of the Silver Nitrate test and of the heat test, nothing but a careful, critical, practical trial will suffice. For example: a saturated solution of Calcium Sulphate in distilled water is so dilute and contains a substance comparatively so inert, that one would *a priori* imagine that here would be an excellent, simple ink. The substance is easily procured, the ink easily made, the development is very special—treatment with a solution of Sodium Alizarin Sulphonate or, better, of Boroalizarinate of Sodium. Unfortunately, this writing fails to pass the heat and the Silver Nitrate tests.

Occasionally, though rarely, a simple ink will pass the heat and the Silver Nitrate tests, but will fail with one of the others. This, however, may be predicted in practically every instance and the difficulty may then be turned by working out a compound process on the same basis.

In the nature of things, an ink which will suit all the requirements we have laid down, must be rare. Perhaps the best example is an extreme dilution of blood in water (1 to 20,000 or even more dilute). Messages written with such a fluid are invisible when dry, they do not respond to any routine test, they are quite permanent.

Care must be taken to use distilled or very soft water. If such is not available, the paper must receive a preliminary dip in the water, followed by drying. This, however, strictly speaking, places the process in the "compound" class. The development of the writing depends on the peroxidase reaction. The most sensitive agent for eliciting this is Phenolphthalin. In practice, however, I have found that, for detecting writing, the less sensitive Benzidin test is superior. This is performed as follows:

A pinch of Benzidin (C. P. "for blood") is dissolved to saturation in glacial Acetic Acid and to the solution is added not more than an equal volume of Hydrogen Peroxide, U. S. P. This reagent must be fresh and used immediately. The reagent is poured over the suspected spot and the writing will flash up blue. It will soon disappear, so it is necessary to test and read a small portion at a time.

COMPOUND PROCESSES

As already stated, compound methods are those in which more than one operation on the paper is necessary in preparing the writing.

Some of these methods are compound in their essential nature, that is to say the writing, upon which the developer is eventually to act, cannot be produced by a single operation. In other instances, the basis of the method is simple, but owing to the fact that the simple message would not pass the routine tests, it is necessary to convert it into a compound method by means of operations intended to baffle the examiner.

An example of the inherently compound class is the following:

It is a fact, though not widely known, that if a photographic sensitive surface be exposed, and immediately fixed and washed (without development), it can be dried and exposed freely to the light and yet, at any time that may be desired, the image may be developed by suitable methods. This was discovered by the present writer to be one of the methods by which, in peace time, forbidden photographs, and especially prohibited cinematograph pictures, were transmitted from place to place. There are various modifications of the process.

The following seems to be the best: A double-coated film is sensitized on one side to red or to green light. On this is printed (by red or green light, respectively) an "innocent" picture, which is then developed. The surface which is not specially color sensitive will evidently show no image. The whole film is now washed and dried and is then exposed again, this time from the other side, to the forbidden image, the exposure being about ten times the normal. The whole is now fixed. Such a film has the appearance of bearing merely an innocent picture, no trace of the second image being visible. It must be remembered that films with gelatin coating on the two sides are not sufficiently uncommon to attract attention. On arrival at its destination, the film is treated in one or other of a number of obvious methods for the removal of the innocent image and the forbidden image is then developed by a physical developer or intensifier.

It is evident that this process or some modification of it can be applied for the transmission of concealed information, either in the form of images or words. Here are two such methods:

For images.—Bromide paper is exposed for ten times the normal period to the "secret" image. It is fixed in weak (2½ to 5 per cent) hypo and washed very thoroughly. It is now immersed for fifteen minutes in a solution made by diluting formaldehyde U. S. P. twenty times with distilled water. After this, it again is washed and dried.

An "innocent" picture may now be floated on to the surface of this concealed picture by one of the numerous transfer processes. A better, though more difficult method is to prepare slow gelatino-bromide emulsion, without hardening agent, and to coat this over the hidden image. This re-coated paper, when dry, is exposed to an innocent negative, developed, washed, exposed to the light, and fixed with weak hypo in the usual way. Such a paper presents the appearance of an ordinary photograph.

To develop the concealed image, it is placed first in the warm water, and the second coating, which is now softened, is removed by gently rubbing with the finger. The now blank paper is placed in a physical developer or intensifier. Of these there are a number in use, of which the most reliable and the cleanest, is the Mercuric Bromide-Metol developer of Seyewetz, which has the following composition:

A. Mercuric Bromide	9
Sodium Sulphite (dry)	180
Water	1000

(For Mercuric Bromide, the equivalent of Mercuric Chloride and Potassium Bromide may be substituted.)

B. Metol (Amidol or Hydroquinone)	5
Sodium Sulphite (dry)	5
Water	250

Take one part of B to five parts of A.

Development will be slow or rapid, according to the nature of the paper and the amount of exposure it has received.

For writing.—Paper of good quality is soaked in 5 per cent aqueous solution of Potassium Bromide, dabbed off with blotting paper, and dried. On this message is written with 2 per cent solution of Silver Nitrate, using a gold or glass pen and working in a dim light. When dry, the writing is exposed for a short time to a bright light. It is better to give it a rinse in distilled water before this operation. Fix in weak hypo for five minutes, and rinse thoroughly. On drying, there must be no sign of the writing visible. Develop with the physical developer given above.

As an example of the second class of compound methods, that is, where additional operations are employed to disguise or to render difficult the detection of a simple writing the following instances will suffice:

A substance, known as agar-agar or Japanese seaweed isinglass, has the following properties: First, it absorbs a very large amount of water in the cold, without dissolving; secondly, an agar-agar jelly melts at a much higher temperature than a gelatin jelly of the same consistency. Agar resists absolutely all ferments and microbes, it is entirely indigestible; gelatin, on the other hand, is very readily digested. In most other respects, so far as our present purposes are concerned, agar resembles gelatin. One, gelatin is a common, the other, agar, is an occasional constituent of paper size.

From consideration of these facts, it is evident that we can ring the changes to an immense variety of secret writing methods. There is one point, however, to be borne in mind: agar and gelatin differ slightly in their dye affinities (chromatophily). This does not really present much inconvenience, nor is there much trouble in bringing them to a common dyeing character by incorporating, in both, a suitable mordant.

Specifically: make an agar jelly of 1½ per cent in water: make a gelatin jelly of 5 per cent in water. To each add an equal quantity of 1 per cent aqueous solution of Aluminium Sulphate. Write your message on smooth paper with hot agar jelly and, when the writing is dry, dip the paper in the warm gelatin solution, mop off the excess with blotting paper and dry. Should this impart a suspiciously crisp crackle to the paper, add 2½ per cent of glycerine to your alumed gelatin size.

There are a number of ways of developing this writing. One of the simplest methods is to dip the surface of the paper momentarily in a solution of Sodium Alizarin Sulphonate (alizarin carmine) of about the color of strong, black tea. Then dip the paper in warm water and let it stay in the air for five minutes. Place the paper now in a dish of hot water, or in running hot water, and rub the surface gently with the finger or with a pad of cotton. The message will appear in white (if the paper is white) on a pink ground.

For the gelatin size, in the above method, may be substituted a solution of albumin which is coagulated on the paper by heat. The development in this case is less simple as it involves the use of a digestive ferment, preferably trypsin. This will remove the albumin, leaving the writing in agar jelly.

Another example of a compound process, this time using an inorganic base, is the following: Barium Sulphate is suspended in thin gelatin solution and the writing is executed with this. The paper is now sized with a gelatine size, containing Barium Carbonate in suspension. Development depends on the well known fact that Barium Sulphate is insoluble in acids, while the carbonate is readily dissolved. After the removal of the carbonate, the presence of the sulphate may be revealed in a variety of ways. There are, for example, certain dyes which will be adsorbed by it or, again, its presence may be detected by taking an x-ray photograph with a very short exposure.

MODIFICATION OF THE INK OF OPEN WRITING.

An important means for secret communication consists in modification of parts of the ink of an "open" writing. It is not feasible to deal exhaustively with all the possibilities. A few examples will show what may be done.

Mercuric Sulphide is a black substance which would respond to all the chemical tests, to which it is likely to be submitted, in much the same way as would carbon, for which it may therefore be substituted. Sulphide of Cobalt will behave in a similar manner, except that it is dissolved, though with some difficulty, by strong mineral acids. If two inks are made up in one of which the pigment is Mercuric Sulphide and in the other Cobalt Sulphide, adding to each a small quantity of blue pigment or dye, to produce the bluish-black which we are accustomed to perceive as black, and the other necessary constituents (gum and glycerine for writing, vaseline, turpentine, etc., for typewriter ribbons—boiled oil and varnish for printing inks) the two inks can be brought to a perfect match. Some Cobalt ink may be mixed with the Mercuric ink, so that the difference in the granularity in the two products may be level. You now have two inks: 1. Containing Mercuric and Cobalt Sulphides. 2. Containing Cobalt Sulphide only. An "innocent" communication may now be prepared with these two inks which will appear, to the naked eye, under the microscope and to the routine reagents, as being written in one kind of ink, but, if strong nitric acid be applied to the paper, the parts of the writing written with a pure Cobalt Sulphide ink will become much lighter, even if they are not completely dissolved. There are several ways in which advantage may be taken of this fact:

1—By a modification of the grille cipher, the permanent parts of the writing may spell out a message.

2—By use of the biliteral cipher, the permanent parts being A forms, the soluble parts B forms or vice-versa.

3—By employing the Morse code. The easiest modification of this is to have a convention with two permanent letters together forming a dash, one permanent letter a dot, one soluble letter a space between the dot and the dash, two soluble letters a space between letters. There is really no need for a convention on this matter, for any one with a keen, investigating mind would recognize the alternation of shorts and longs, and suspect the use of the Morse code. This method is easiest applied on the typewriter, because the letters, being separate, do not betray the signs of junction, as may occur when handwriting of this kind is examined under the microscope.

To prepare ribbon for this purpose, white taffeta ribbon of suitable width is laid on a sheet of glass and the ink is thoroughly rubbed in with a tooth brush. The ribbon is then hung up to dry. When dry, a sufficient length is held in a small frame or the usual ribbon can be removed from the typewriter. A piece of paper being placed in the machine, the two ribbons (soluble and insoluble ink) are tested against one another and, by rubbing down on blotting paper, are made to produce an exact match. The message must be written soon, as ribbons made in this fashion rapidly change in their inking qualities, and the match may be lost. It is evident that the ribbon with which an impression is desired to be made must be held so that the type strikes it as it would the normal ribbon of the machine. It is better not to trust to the accuracy with which the machine is capable of returning the paper to the same position, but to use the ribbon as their turn comes, and not make first a line with one and return to fill up the gaps with the other. With a double ribbon machine, the two halves of a wide ribbon may be separately inked.

Another method, specially suitable for use with a typewriter, depends on the fact that typewriter ribbon ink may be made either with a greasy or with a watery vehicle. The greasy vehicle may be vaseline with the necessary amount of spirit of turpentine and benzoin, while the watery vehicle is usually glycerine thinned, for purposes of application, with alcohol. While it is difficult, it is not impossible to make a satisfactory black ink of the glycerine class. It is considerably easier to make a colored ink in this way.

There are two ways of availing one's self of the difference in these two kinds of inks. The first is to use two ribbons (or a double inked ribbon) on the typewriter, both of them carrying an ink. This, however, involves the really difficult task of producing a good match. A better method is to have only one of the inks—the glycerine one colored and have the other ribbon charged lightly with vaseline.

Having written a line with the inked ribbon, you now go back over the same line with the greased ribbon, striking only the characters which you wish to distinguish.

Such a writing presents no visible peculiarities and behaves on routine examination just in such a manner as not to reveal its secret. If, however, it be "pounced" with jewelers' rouge, the dark red powder will adhere to the characters which have been struck with a greasy ribbon and not to the others.

Should the writing be old, the greasiness may be revived by leaving it, for a short time, in an atmosphere of one of the volatile oil solvents. It is evident that no drying oil should be used with such a ribbon.

The same principle may be applied to the modification of handwriting or of print. For this, dissolve white vaseline in 10 parts of a mixture in equal parts of spirits of turpentine and benzol. Rub this thoroughly into a thin sheet of white paper and hang up the latter to evaporate the solvents. The result is a translucent sheet of paper whose surface is greasy, but which does not grease another surface in contact with it except on pressure.

Lay this over the open writing and, with a style or pencil, mark the letters as desired.

But for the conveying of messages by the concealed modification of hand writing, the most subtle and satisfactory, as well as the simplest, is to touch the chosen letters with some chemical solution which does not alter their appearance, nor their ordinary reactions to the routine agents, but which can be revealed by special methods. The more specific the special methods are, the better. I will, therefore, go at once to what I believe to be the most specific of all these cases.

A solution of a Nickel salt, even in extreme dilution, will give a red color or precipitate on the addition of Dimethylglyoxime in ammoniacal alcohol. The same result can be obtained by treating writing in a Nickel ink on paper. The method is not, however, available as a "simple" method, because the first dilution which does not give any reaction with the routine reagents, is an ink of 1 in 10,000. Nickel Sulphate and, unfortunately, at this dilution, the reaction *on paper* with Dimethylglyoxime is uncertain.

But, if an open message is written with an ordinary gallotannic ink and, when the writing is dry, the selected letters are marked carefully with a fine pen carrying a 1 in 500 solution of Nickel Sulphate, the result is an invisible message practically undetectable except by the special reaction named above. This reaction is applied in the following manner: the paper (slightly dampen the back) is placed in the bottom of a flat dish: the surface is treated with a 5 per cent solution of Dimethylglyoxime in ammoniacal alcohol: the dish is then heated in the water bath or any other means. The selected letters will now appear redder than the others, but the difference is not very great. To develop it more clearly, the sheet is rinsed with warm water and placed in dilute Oxalic acid. The ordinary ink will now disappear, leaving the bright pink marks of Nickel Dimethylglyoxime.

Enough has now been said to indicate the lines along which the worker must direct his investigations in order to develop new methods and combinations of methods for the production of invisible messages and images by chemical means.

Once more let me impress upon him that the essentials of such a method are: 1. Novelty. 2. Non-detectability by routine methods. 3. Unsuspicious appearance. 4. Certainty.

The above are essential, the following are desirable: 1. Simplicity at the sending end. 2. Ready availability of the materials for writing. 3. Difficulty of development, even when the method is known.

MESSAGES INCORPORATED IN THE PAPER.

The Making of Special Paper

The following instructions, if carefully followed, will suffice to produce a paper of high quality, as judged by our present standards. It will not produce a strong paper, because the fibre used will not be of the length and quality demanded for that purpose.

Take a sufficiency of high quality filter paper. Tear (not cut) it up into fragments about ¼ of an inch by ½ inch and place in hot water, preferably distilled, in a stoppered jar. Shake thoroughly; the paper will be disintegrated, reproducing the pulp from which it was originally made. Knots should be removed as far as possible. The pulp should be again shaken up and allowed to rest for one-half minute, when the supernatant fluid with the suspended fibres should be poured off into another jar, and the process recommenced in the first jar. In the second jar the pulp will gradually settle and the liquid can be decanted. In this way a quantity of pulp, sufficient for our purpose can be collected. When enough has been made, we can proceed to the next step. A frame should be made with its internal dimensions not less than ½ inch larger in each direction than the paper you wish to produce. On this will be stretched the wire cloth or wires, according to the kind of paper that you wish to produce. The fastening of the cloth must be on the under surface of the frame, so that the upper surface is flush. This is easiest effected by using the angle stretchers supplied by dealers' and artists' material. A similar frame, called a deckle, but without wire cloth is made of the same dimensions as the wired frame.

On this wire cloth is soldered or otherwise fixed, temporarily or permanently, the wire forming the water mark or conveying a message in cipher or in the Morse code. The uniformly suspended pulp is placed in a deep vessel of the general shape of a photographic developing dish. The frame and deckle held together, the latter uppermost, are now plunged into the suspension of pulp until a sufficiency of the latter stands over them. Holding them strictly level, the frame and deckle are now withdrawn slowly from the fluid, while imparting to them a horizontal jigging motion in all directions; the water gradually drains away through the wires, leaving the sheet of pulp evenly distributed over the wire cloth. The jigging motion has caused the fibres to felt themselves thoroughly over the wires. Over the wires of the cloth or of the water mark, the layer of pulp is naturally thinner and the finished paper will, in these places, be more translucent. When the water has drained away, the deckle is removed. The frame is laid pulp down a sheet of felt and by a sharp movement, the knack of which is easily acquired, the thin wet paper is transferred to the felt. Another sheet of felt is laid over this and the process is recommenced. When the felt has taken up most of the water from the sheet so that it can be handled without rupture, the latter is hung up to dry. When dry, it is immersed in a thin, warm solution of gelatin, containing a small quantity of alum; the excess of size is removed and the paper is again dried. The next process corresponds to the calendering of the paper maker, and is best effected either by a photographer's burnishing roll, or by a large, not too hot, flat iron.

The sheet of paper so made, will have a thin irregular edge (the deckle edge), familiar to the users of hand made paper. For our purpose this will generally require removal. By choosing among a number of sheets, one will always be found sufficiently thin and uniform in body, not to attract attention or raise suspicion of its being especially prepared paper. A water mark produced in this way is a true water mark. The majority of water marks on modern papers are not produced in this way, but by the pressure of a wire pattern on the wet sheet as it leaves the wire cloth of the paper machine (on the dandy-roll). Such a paper has already been sized, the sizing having been mixed with the pulp before the latter reaches the wire cloth. Still further removed from the true water mark is another kind most often used for the production of a trade brand on paper. This is produced by pressure at a much later stage of the process and the result is easily distinguished by the sharpness and uniformity of the impression. These marks resemble, both in their method of production and in their appearance, the forged water mark employed in the counterfeiting of documents of value. These last are, however, sometimes produced by chemicals, with which process we have no present concern.

INDICATIONS FOR FURTHER WORK

1. ***Blood,*** diluted with water 20 to 50 thousand times.
   Developed with Benzidine and Peroxide of Hydrogen.
   The undeveloped writing is permanent, but after development it rapidly disappears.

2. ***Nickel*** Salt, 1 in 10,000 in water.
   Developed with Ammoniacal-alcohol solution of Dimethylglyoxime.
   Writing, developed and undeveloped, permanent.
   The process is capricious, probably owing to slight differences in the paper surface. At greater concentrations the writing is detected by the routine tests. The developed writing is more clearly seen if examined by minus-red light (Cooper-Hewitt light or blue-green filter).
   See Compound Methods.

3. ***Cobalt*** Salt, 1 in 10,000 in water.
   Developed with Alphanitrosobetanaphthol in Acetic acid.
   More capricious than 2.

4. ***Phenylhydrazine*** very dilute solution in water.
   Developed with Formaldehyde, Sodium Nitroprusside and Sodium Hydrate.
   The process is not capricious, but the margin between the concentration at which routine detection takes place and that at which the specific reagent is necessary and useful is narrow and varies. The suitable concentration must therefore be determined for each sample of phenylhydrazine and for each paper.

5. ***Hexamethylenaminetetramine*** (Urotropine) dilute solution in water.
   Developed with Bromine vapor.
   Same remark as for 4.

(NOTE.—These last two processes, as well as a number of others which will occur to the worker when he takes up this particular field of the work, such as the formaldehyde reactions and those of antipyrin, are worth working up for compound processes. As simple processes they are not reliable.)

6. Boroalizarinate of Sodium is an exquisitely sensitive reagent for Calcium salts. On some papers, a suitable dilution of Calcium Sulphate furnishes an ink not detected by routine methods.

7. Hammersten's reaction for bile pigment might be worked up as a method for secret writing.

8. ***Ultramarine*** is unaffected by alkalies and by alkaline sulphides. It is dissolved by dilute mineral acids.

   Prussian Blue is removed (yellow orange residue) by alkali, blackened by alkaline sulphides. It is unaffected by dilute mineral acids.