SIX LECTURES ON CRYPTOLOGY

by

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FOREWORD

These six lectures by Mr. William F. Friedman, dean of American cryptologists, were prepared under an NSA contract in order to have the history of cryptology recorded by one who, perhaps more than any other in our country, has played a vital role in this field. It is hoped that both new and old employees may be inspired with a feeling of belonging to an ancient profession—one that abounds in drama and fascination, and one that has had a profound impact on the turn of events in history. The lectures are published here for the first time in one volume.

CONTENTS

Lecture I

The objective of this series of lectures is to create an awareness of the background, development, and manner of employment of a science that is the basis of a *vital military offensive and defensive weapon* known as CRYPTOLOGY, a word that comes from the Greek *kryptos*, meaning *secret* or *hidden*, plus *logos*, meaning *knowledge* or *learning*. Cryptology will be specifically defined a little later; at the moment, however, I'm sure you know that it has to do with *secret communications*.

Let me say at the outset of these lectures that I may from time to time touch upon matters which are perhaps essentially peripheral or even irrelevant to the main issues, and if a defense is needed for such occasional browsing along the byways of the subject, it will be that long preoccupation with any field of knowledge begets a curiosity the satisfaction of which is what distinguishes the dedicated professional from the person who merely works just to gain a livelihood in whatever field he happens to find himself a job. That's not much fun, I'm afraid. By the way, a British writer, James Agate, defines a professional as the man who can do his job even when he doesn't feel like doing it; an amateur, as a man who can't do his job even when he does feel like doing it. This is pretty tough on the gifted amateur and I for one won't go all the way with Agate's definition. There are plenty of instances where gifted amateurs have done and discovered things to the chagrin and red-facedness of the professionals.

Coming back now to the main thoroughfare after the foregoing brief jaunt along a byway, I may well begin by telling you that the science of cryptology has not always been regarded as a vital military offensive and defensive weapon, or even as a weapon in the first place. Here I am reminded of a story in a very old book on cryptography. The story is probably apocryphal, but it's a bit amusing, and I give it for what it's worth.

It seems that about two thousand years ago there lived a Persian queen named Semiramis, who took an active interest in cryptology. She was in some respects an extraordinarily unpleasant woman, and we learn without surprise that she met with an untimely death. She left behind her instructions that her earthly remains were to be placed in a golden sarcophagus within an imposing mausoleum, on the outside of which, on its front stone wall, there was to be graven a message, saying:

> Stay, weary traveller!
> If thou art footsore, hungry, or in need of money—
> Unlock the riddle of the cipher graven below,
> And thou wilt be led to riches beyond all dreams of avarice!

Below this curious inscription was a cryptogram, a jumble of letters without meaning or even pronounceability. For several hundred years the possibility of sudden wealth served as a lure to many experts who tried very hard to decipher the cryptogram. They were all without success, until one day there appeared on the scene a long-haired, bewhiskered, and bespectacled savant who, after working at the project for a considerable length of time, solved the cipher, which gave him detailed instructions for finding a secret entry into the tomb. When he got inside, he found an instruction to open the sarcophagus, but he had to solve several more cryptograms the last one of which may have involved finding the correct combination to a 5-tumbler combination lock—who knows? Well, he solved that one too, after a lot of work, and this enabled him to open the sarcophagus, inside which he found a box. In the box was a message, this time in plain language, and this is what it said:

O, thou vile and insatiable monster! To disturb these poor bones!
If thou hadst learned something more useful than the art of deciphering,
Thou wouldst not be footsore, hungry, or in need of money!

I'm frank to confess that many times during my 40-year preoccupation with cryptology, and generally near the middle and the end of each month, I felt that good old Queen Semiramis knew what she was talking about. However, earning money is only a part of the recompense for working in the cryptologic field, and I hope that most of you will find out sooner or later what some of these other recompenses are, and what they can mean to you.

If Queen Semiramis thought there are other things to learn that are more useful than the art of deciphering, I suppose we'd have to agree, but we are warranted in saying, at least, that there isn't any question about the importance of the role that cryptology plays in modern times: all of us are influenced and affected by it, as I hope to show you in a few minutes.

I shall begin by reading from a source which you'll all recognize—*Time*, the issue of 17 December 1945. I will preface the reading by reminding you that by that date World War II was all over — or at least V-E and V-J days had been celebrated some months before. Some of you may be old enough to remember very clearly the loud clamor on the part of certain vociferous members of Congress, who had for years been insisting upon learning the reasons why we had been caught by surprise in such a disastrous defeat as the Japanese had inflicted upon us at Pearl Harbor. This clamor had to be met, for these Congressmen contended that the truth could no longer be hushed up or held back because of an alleged continuing need for military secrecy, as claimed by the Administration and by many Democratic senators and representatives. The war was over — wasn't it? — Republican senators and representatives insisted. There had been investigations—a half dozen of them—but all except one were *Top Secret*. The Republicans wanted—and at last they got what they desired—a grand finale Joint Congressional Investigation which would all be completely open to the public. No more secrets! It was spectacular. Not only did the Congressional Inquiry bring into the open every detail and exhibit uncovered by its own lengthy hearings, but it also disclosed to America *and to the whole world* everything that had been said and shown at all the previous Army and Navy investigations. Most of the information that was thus disclosed had been, and much of it still, was *Top Secret*; yet all of these precious secrets became matters of public information as a result of the Congressional Investigation.

There came a day in the Congressional Hearings when the Chief of Staff of the United States Army at the time of the Pearl Harbor Attack, 5-star General George C. Marshall, was called to the witness stand. He testified for several long, long days, eight of them in all. Toward the end of the second day of his ordeal he was questioned about a letter it had been rumored he'd written to Governor Dewey in the Autumn of 1944, during the Presidential Campaign. The letter was about codes. With frozen face, General Marshall balked at disclosing the whole letter. He pleaded most earnestly with the Committee not to force him to disclose certain of its contents, but to no avail. He had to bow to the will of the majority of the Committee. I shall now read from *Time* a bit of information which may be new to many of my listeners, especially to those who were too young in December 1945 to be delving into periodical literature or to be reading any pages of the daily newspaper other than those on which the comics appear.

Said *Time*, and I quote:

> "'U.S. citizens discovered last week that perhaps their most potent secret weapon of World War II was not radar, not the VT fuse, not the atom bomb, but a harmless little machine which cryptographers had painstakingly constructed in a hidden room in Washington. With this machine, built after years of trial and error, of inference and deduction, cryptographers had duplicated the decoding devices used in Tokyo. Testimony before the Pearl Harbor Committee had already shown that the machine, known as '*Magic*', was in use long before December 7, 1941,

and had given ample warning of the Jap's sneak attack, if only U.S. brass hats had been smart enough to realize it. Now, General Marshall continued the story of '*Magic's*' magic:

1. 'It had enabled a relatively small U.S. Force to intercept a Jap invasion fleet, win a decisive victory in the Battle of the Coral Sea, thus saving Australia and New Zealand.

2. 'It had directed U.S. submarines unerringly to the sea lanes where Japanese convoys would be passing.

3. 'It had given the U.S. full advance information on the size of the Jap forces advancing on Midway, enabled our Navy to concentrate ships which otherwise might have been 3,000 miles away, thus set up an ambush which proved to be the turning-point victory of the Pacific war.

4. 'By decoding messages from Japan's Ambassador Oshima in Berlin, often reporting interviews with Hitler, it had given our forces invaluable information on *German* war plans.'"

Time goes on to give more details of that story, to which I may later return but I can't leave this citation of what cryptology did toward our winning of World War II without telling you that the account given by *Time* of the achievements of *Magic* makes it appear that *all* the secret intelligence gained from our reading Japanese messages was obtained by using that "harmless little machine" which *Time* said was used in Tokyo by the Japanese Foreign Office. I must correct that error by explaining first that *Magic* was not the name of the machine but a term used to describe the intelligence material to which the machine, among other sources, contributes and then by telling you that the secret information we obtained that way had little to do with those portions of the *Magic* material which enabled our Navy to win such spectacular battles as those of the Coral Sea and Midway, and to waylay Japanese convoys. The naval parts of *Magic* were nearly all obtained from Japanese naval messages by our own very ingenious U.S. Navy cryptanalysts. At that time, I may tell those of you who are new, the Army and Navy had separate but cooperating cryptologic agencies and activities; the United States Air Force was not yet in existence as an autonomous and separate component of the Armed Forces, and work on Japanese, German, and Italian Air Force communications was done by Army cryptanalysts, admirably assisted by personnel of what was then known as the Army Air Corps.

It is hardly necessary to tell you how carefully the *Magic* of World War II was guarded before, during, and after the war until the Congressional Inquiry brought most of it out in the open. Some remaining parts of it are still very carefully guarded. Even the fact of the existence of *Magic* was known to only a *very* few persons at the time of Pearl Harbor — and that is an important element in any attempt to explain why we were caught by surprise by the Japanese at Pearl Harbor in a devastating attack that crippled our Navy for many months. Let me read a bit from page 261 of the Report of the Majority of the Joint Congressional Investigation of the attack:

> "The *Magic* intelligence was pre-eminently important and the necessity for keeping it confidential cannot be overestimated. However, so closely held and top secret was this intelligence that it appears that the *fact* that the Japanese codes had been broken was regarded as of more importance than the *information* obtained from decoded traffic."

Time says, in connection with this phase of the story of *Magic* during World War II:

> "So priceless a possession was *Magic* that the U.S. high command lived in constant fear that the Japs would discover the secret, change their code machinery, force U.S. cryptographers to start all over again."

Now I don't want to overemphasize the importance of communication intelligence in World War II, but I think it warranted to read a bit more of what is said about its importance in the Report of the Majority. The following is from p. 232:

> ". . . all witnesses familiar with *Magic* material throughout the war have testified that it contributed enormously to the defeat of the enemy, greatly shortened the war, and saved many thousands of lives."

General Chamberlin, who was General MacArthur's operations officer, or G–3, throughout the war in the Pacific, has written: "The information G–2, that is, the intelligence staff, gave

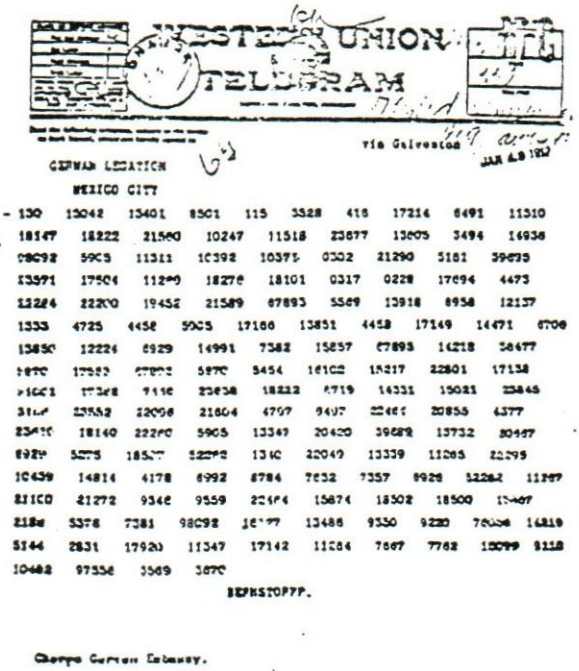
ra in the Pacific Theater alone saved us many thousands of lives and shortened the war by no less than two years." We can't put a dollars-and-cents value on what our possession of COMINT meant in the way of saving lives; but we can make a dollars-and-cents estimate of what communications intelligence meant by shortening the war by two years, and the result of that estimate is that it appears that $1.00 spent for that sort of intelligence was worth $1,000 spent for other military activities and materials.

In short, when our commanders had that kind of intelligence in World War II they were able to put what small forces they had at the right place, at the right time. But when they didn't have it—and this happened, too—their forces often took a beating. Later on we'll note instances of each type.

I hope I've not tried your patience by such a lengthy preface to the real substance of this series of lectures; let's get down to brass tacks. For those of you who come to the subject of cryptology for the first time, a few definitions will be useful, in order that what I shall be talking about may be understood without question. Agreement on basic terminology is always desirable in tackling any new subject. In giving you the definitions there may be a bit of repetition because we shall be looking at the same terms from somewhat different angles.

First, then, what is cryptology? Briefly, we may define it as the doctrine, theory, or branch of knowledge which treats of hidden, disguised, or secret communications. You won't find the word in a small dictionary. Even Webster's Unabridged defines it merely as "secret or enigmatical language"; and in its "Addenda Section," which presumably contains new or recently coined words, it is defined merely as "the study of cryptography." Neither of these definitions is broad or specific enough for those who are going to delve somewhat deeply into this science.

Cryptology has two main branches: the first is cryptography, or, very briefly, the science of preparing secret communications; and the second is cryptanalysis, or the science of solving secret communications. Let's take up cryptography first, because as a procedure it logically precedes cryptanalysis: before solving anything there must be something to solve.



WESTERN UNION
TELEGRAM

via Galveston

GERMAN LEGATION
MEXICO CITY

130 13042 13401 8501 115 3528 416 17214 6491 11310
18147 18222 21560 10247 11518 23677 13605 3496 14936
09092 5905 11311 10392 10375 0302 21290 5161 39039
13971 17504 11299 18276 18101 0317 0228 17694 4473
12284 22200 19452 21589 07893 5569 13918 8958 12137
1333 4725 4458 5905 17166 13851 4458 17149 14471 6706
13850 12224 6929 14991 7382 15857 07893 14218 36477
1870 17252 07893 5870 5454 16102 15217 22801 17138
21001 17348 9110 23458 18313 6719 14331 15021 23846
3147 23552 22096 21604 4797 9407 22464 20855 4377
23610 18140 22260 5905 13347 20420 39684 13732 20667
6929 5275 18507 12284 1340 22040 13339 11265 22295
10439 14814 4178 6992 6784 7632 7357 6928 12282 11297
21100 21272 9346 9559 22464 15874 18502 18500 15857
2188 5376 7381 98093 16177 13486 9350 9220 76036 14819
5144 2831 17920 11347 17142 11284 7667 7762 15099 9118
10482 97356 3569 3870

BERNSTORFF.

Charge German Embassy.

Figure 1.—The Zimmerman Telegram.

Cryptography is that branch of cryptology which deals with the various means, methods, devices, and machines for converting messages in ordinary, or what we call plain language, into secret language, or what we call cryptograms. Here's a picture of one of the most famous cryptograms in history. It was the solution of this cryptogram which resulted in bringing America into World War I on the side of the Allies on 6 April 1917, just about six weeks after it was solved. I'll tell you about it later in this series.

Cryptography also includes the business of reconverting the cryptograms into their original plain-language form, by a direct reversal of the steps followed in the original transformation. This implies that the persons involved in both of these bits of business, those at the enciphering and sending end, and those at the receiving and deciphering end, have an understanding as to what procedures, devices, and so on, will be used and exactly how—down to the very last detail. The what and the how of the business constitutes what is generally referred to as the *key*. The key may consist of a set of rules, alphabets, procedures, and so on; it may also consist of an ordinary book which is used as a source of keys; or it may be a specialized book, called a *code book*. That cryptogram I just showed you was made by using a book—a German codebook.

To *encrypt*, is to convert or transform a plaintext message into a cryptogram by following certain rules, steps, or processes constituting the key or keys and agreed upon in advance by the correspondents, or furnished them by higher authority.

To *decrypt* is to reconvert or to transform a cryptogram into the original equivalent plaintext message by a direct reversal of the encrypting process that is, by applying to the cryptogram the key or keys, usually in a reverse order, employed in producing it.

A person who encrypts and decrypts messages by having in his possession the necessary keys, is called a *cryptographer*, or a *cryptographic clerk*.

Encrypting and decrypting are accomplished by means collectively designated as *codes and ciphers*. Such means are used for either or both of two purposes: (1) secrecy, and (2) economy. Secrecy usually is far more important in diplomatic and military cryptography than economy, but it *is* possible to combine secrecy and economy in a single system. Persons technically unacquainted with cryptology often talk about "cipher codes," a term which I suppose came into use to differentiate the term "code" as used in cryptology from the same term as used in other connotations, as, for example, the Napoleonic Code, a traffic code, a building code, a code of ethics, and so on. Now, in cryptology, there is no such thing as a "cipher code." There are *codes* and there are *ciphers*, and we might as well learn right off the differences between them, so that we get them straightened out in our minds before proceeding further.

In ciphers, or in cipher systems, cryptograms are produced by applying the cryptographic treatment to individual letters of the plaintext messages, whereas, in codes, or in code systems, cryptograms are produced by applying the cryptographic treatment generally to entire words, phrases, and sentences of the plaintext messages. More specialized meanings of the terms will be explained in detail later, but in a moment I'll show you an example of a cryptogram in cipher and one in code.

A cryptogram produced by means of a cipher system is said to be in *cipher* and is called a *cipher message*, or sometimes, simply a *cipher*. The act or operation of encrypting a cipher message is called *enciphering*, and the enciphered version of the plain text, as well as the act or process itself, is often referred to as the *encipherment*. A cryptographic clerk who performs the process serves as an *encipherer*. The corresponding terms applicable to *decrypting* cipher messages are *deciphering, decipherment, decipherer*.

A cryptogram produced by means of a code system is said to be *in code*, and is called a *code message*. The text of the cryptogram is referred to as *code text*. This act or operation of encrypting is called *encoding*, and the encoded version of the plain text, as well as the act or process itself, is referred to as the *encodement*. The clerk who performs the process serves as an *encoder*. The corresponding terms applicable to the decrypting of code messages are *decod-*

ing, *decodement*, and *decoder*. A clerk who encodes and decodes messages by having in his possession the pertinent code books is called a *code clerk*.

Technically, there are only two distinctly different types of treatment which may be applied to written plain text to convert it into a cipher, yielding two different classes of ciphers. In the first, called *transposition*, the letters of the plain text retain their original identities and merely undergo some change in the relative positions, with the result that the original text becomes unintelligible. Here's an authentic example of a transposition cipher; I call it authentic because it was sent to President Roosevelt and the Secret Service asked me to decipher it. Imagine my chagrin when I had to report that it says "Did you ever bite a lemon?" In the second, called *substitution*, the letters of the plain text retain their original relative positions, but are replaced by other letters with different sound values, or by symbols of some sort, so that the original text becomes unintelligible.

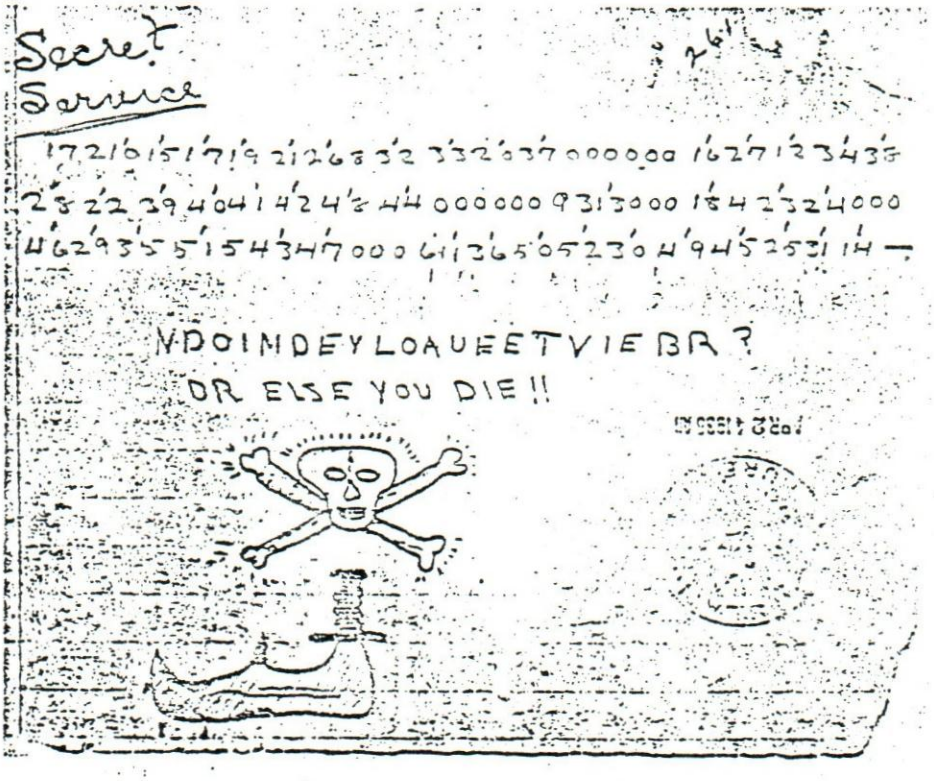


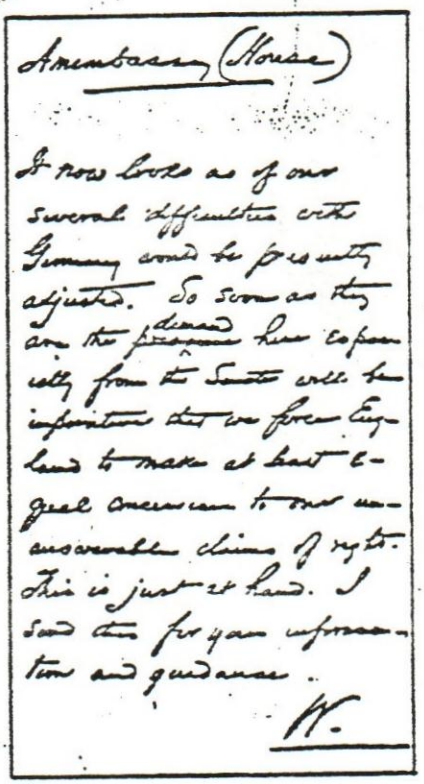
Figure 2.

Nobody will quarrel with you very hard if you wish to say that a code system is nothing but a specialized form of substitution; but it's best to use the word "code" when a code book is involved, and to use "substitution cipher" when a literal system of substitution is used.

It is possible to encrypt a message by a substitution method and then to apply a transposition method to the substitution text, or vice versa. Combined transposition-substitution ciphers do not form a third class of ciphers; they are only occasionally encountered in military cryptography. Applying a cipher to code groups is a very frequently used procedure and we'll see cases of that too.

Now for an example of a cryptogram in code. In Fig. 3 is a plaintext message in the handwriting of President Wilson to his special emissary in London, Colonel House. Contained in Fig. 4 is the cryptogram after the plain text was encoded by Mrs. Wilson. The President himself then typed out the final message on his own typewriter, for transmission by the

Department of State. It would appear that President Wilson lacked confidence in the security of the Department of State's methods—and maybe with good reason, as may be seen in the following extract from a letter dated 14 September 1914 from the President to Ambassador Page in London: "We have for some time been trying to trace the leaks, for they have occurred frequently, and we are now convinced that our code is in possession of persons at intermediary points. We are going to take thoroughgoing measures." Perhaps one of the measures was that the President got himself a code of his own. I must follow this up some day.

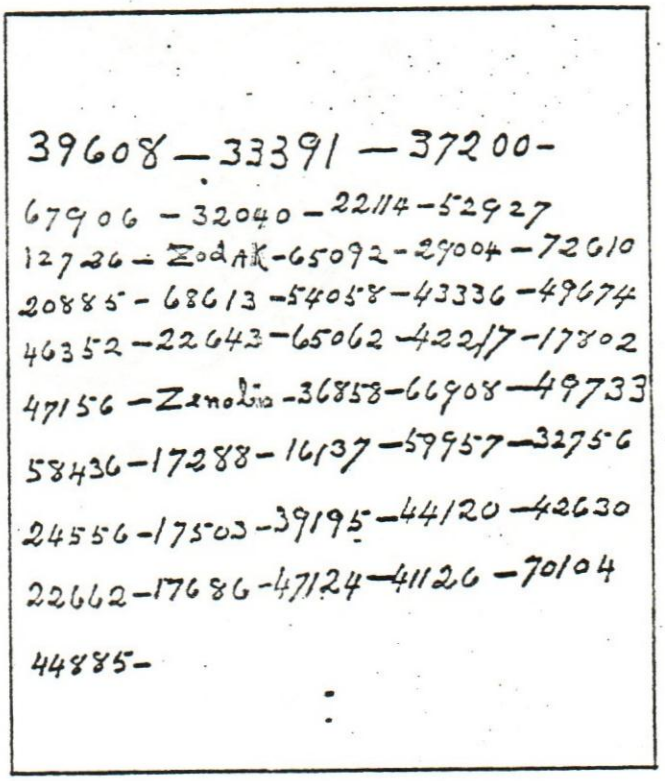


Amembassy (House)

It now looks as if our several difficulties with Germany could be pretty adjusted. So soon as they are the present line of communication from the State will be important that we force England to make at least a good answer to our unanswerable claims of right. This is just at hand. I send this for your information and guidance.

W.

Figure 3.



39608 — 33391 — 37200-
67906 - 32040 - 22114 - 52927
12726 - Zodiak - 65092 - 27004 - 72610
20885 - 68613 - 54058 - 43336 - 49674
46352 - 22642 - 65062 - 42217 - 17802
47156 - Zenobia - 36858 - 66908 - 49733
58436 - 17288 - 16137 - 59957 - 32756
24556 - 17503 - 39195 - 44120 - 42630
22662 - 17686 - 47124 - 41126 - 70104
44885-

Figure 4.

A cipher device is a relatively simple mechanical contrivance for encipherment and decipherment, usually hand-operated or manipulated by the fingers, as, for example, a device with concentric rings of alphabets, manually powered. In Fig. 5 is an example—a cipher device with such rings. I'll tell you about it later. A cipher machine is a relatively complex apparatus or mechanism for encipherment and decipherment, usually equipped with a typewriter keyboard and generally requiring an external power source. Modern cryptology, following the trend in mechanization and automation in other fields, now deals largely with cipher machines, some highly complicated. Fig. 6 shows an example of a modern cipher machine with keyboard and printing mechanism.

One of the expressions which uniformed laymen use, but which you must never use, is "*the* German code," or "*the* Japanese code," or "*the* Navy cipher," and the like. When you hear this sort of expression you may put the speaker down at once as a novice. There are literally hundreds of different codes and ciphers in simultaneous use by every large and important government or service, each suited to a special purpose; or where there is a multiplicity of systems of the same general nature, the object is to prevent a great deal of traffic being encrypted in the same key, thus overloading the system and making it vulnerable to attack by methods and procedures to be mentioned in broad terms in a few moments.

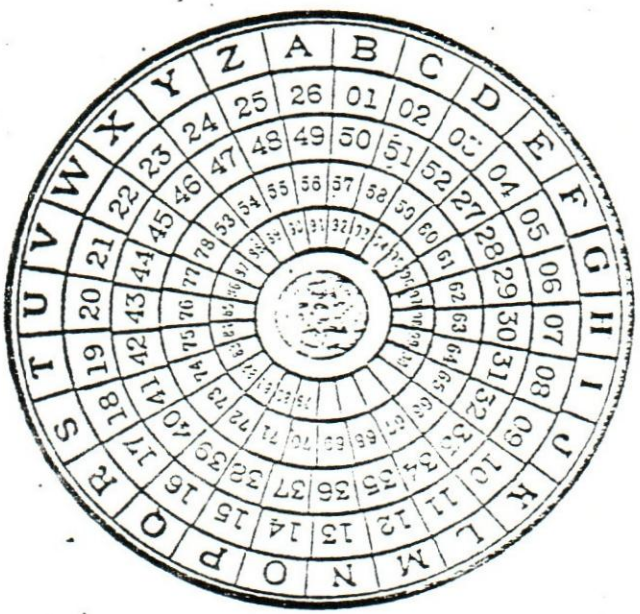

A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26
27 28 29 30 31 32 33 34 35 36 37 38 39 40 41 42 43 44 45 46 47 48 49 50 51 52
53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78

Figure 5.

The need for secrecy in the conduct of important affairs has been recognized from time immemorial. In the case of diplomacy and organized warfare this need is especially important in regard to communications. However, when such communications are transmitted by electrical means, they can be heard or, as we say, *intercepted*, and copied by unauthorized persons, usually referred to collectively as *the enemy*. The protection resulting from all measures designed to deny to the enemy information of value which may be derived from the interception and study of such communications is called *communication security*, or, for short, COMSEC.

In theory, any cryptosystem except one, to be discussed in due time, can be attacked and "broken," i.e., solved, if enough time, labor, and skill are devoted to it, and if the volume of traffic in that system is large enough. This can be done even if the general system and specific key are unknown at the start. You will remember that I prefaced my statement any cryptosystem can be solved by saying "*in theory*," because in military operations theoretical rules usually give way to practical considerations.

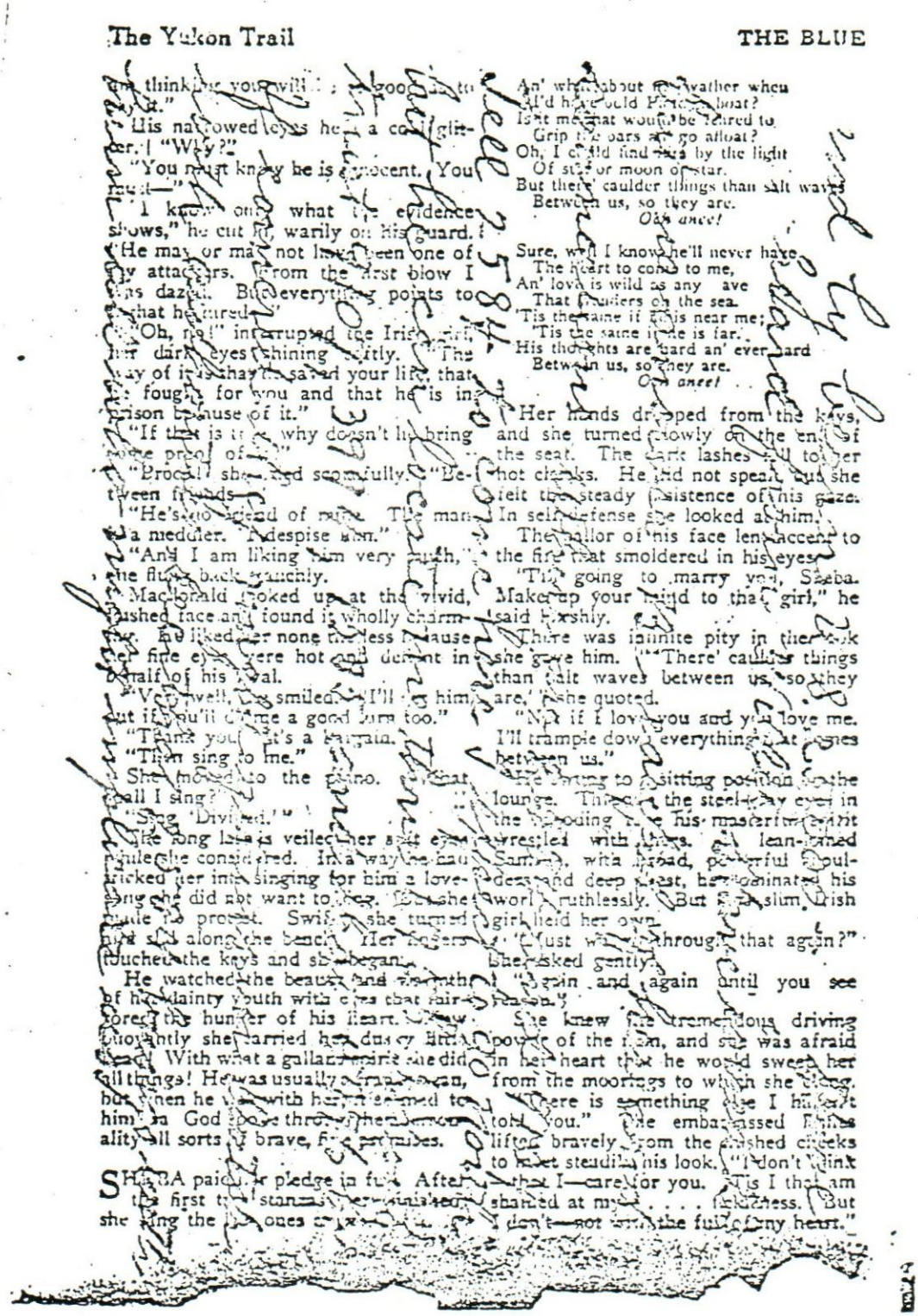
That branch of cryptology which deals with the principles, methods, and means employed in the *solution* or *analysis* of cryptosystems is called *cryptanalytics*. The steps and operations performed in applying the principles of cryptanalytics constitute *cryptanalysis*. To *cryptanalyze* a cryptogram is to solve it by cryptanalysis. A person skilled in the art of cryptanalysis is called a *cryptanalyst*, and a clerk who assists in such work is called a *cryptanalytic clerk*.

Information derived from the organized interception, study, and analysis of the enemy's communications is called *communication intelligence*, or, for short, COMINT. Let us take careful note that COMINT and COMSEC deal with communications. Although no phenomenon is more familiar to us than that of communication, the fact of the matter is that this magic word means many things to many people. A definition of communication that is broad enough for our purposes would be that communication deals with intelligent *messages* exchanged between intelligent beings. This implies that human beings and human operators are involved in the preparation, encryption, transmission, reception, decryption, and recording of messages which at some stage or stages are in written form and in some stage or stages are in electrical form as signals of one sort or another. But in recent years there have come into prominence and importance electrical signals which are not of the sort I've just indicated. They do not carry "messages" in the usual sense of the word; they do not convey from one human being to another an intelligible sequence of words and an intelligible sense. I refer here to electrical or electronic signals such as are employed in homing or directional beacons, in radar, in telemetering or recording data of an electrical or electronic nature at a distance, and so on. Information obtained from a study of enemy electronic emissions of these sorts is called *electronic intelligence*, or, for short, ELINT. COMINT and ELINT comprise SIGINT, that is, *signal intelligence*. Cryptology is the science which is concerned with *all* these branches of secret signalling.

In this series of lectures we shall be concerned only with COMSEC and COMINT, leaving for others and for other times the subject of ELINT. This means that we shall deal with communications or *messages*.

Communication may be conducted by any means susceptible of ultimate interpretation by one of the five senses, but those most commonly used are seeing and hearing. Aside from the use of simple visual and auditory signals for communication over relatively short distances, the usual method of communication between or among individuals separted from another by relatively long distances involves, at one stage or another, the act of writing or of speaking over a telephone.

Privacy or secrecy in communication by telephone can be obtained by using equipment which affects the electrical currents involved in telephony, so that the conversations can be understood only by persons provided with suitable equipment properly arranged for the purpose. The same thing is true in the case of facsimile transmission (i.e., the electrical transmission of ordinary writing, pictures, drawings, maps). Even today there are already simple forms of enciphered television transmissions. Enciphered facsimile is called *cifax*; enciphered telephony, *ciphony*; and enciphered television, *civision*. However, these lectures will not



The Yukon Trail

THE BLUE

think he will . . . good . . . to
it."

His narrowed eyes held a cold glitter. "Why?"

"You must know he is innocent. You must—"

"I know only what the evidence shows," he cut in, warily on his guard. "He may or may not have been one of my attackers. From the first blow I was dazed. But everything points to that he injured—"

"Oh, no!" interrupted the Irish girl, her dark eyes shining softly. "The way of it is, that he saved your life, that he fought for you and that he is in prison because of it."

"If that is true, why doesn't he bring some proof of—"

"Proof!" she cried scornfully. "Between friends—"

"He's no friend of mine. The man is a meddler. I despise him."

"And I am liking him very much," she flung back hotly.

MacDonald looked up at the vivid, flushed face and found it wholly charming. He liked her none the less because her fine eyes were hot and defiant in behalf of his rival.

"Very well," he smiled. "I'll . . . him, but if you'll . . . me a good turn too."

"Thank you . . . it's a bargain."

"Then sing to me."

She moved to the piano. "What shall I sing?"

"Sing 'Divided.'"

The long lashes veiled her soft eyes while she considered. In a way he had tricked her into singing for him a love-song she did not want to . . . She made no protest. Swiftly she turned and slid along the bench. Her fingers touched the keys and she began.

He watched the beauty and the pathos of the dainty youth with eyes that narrowed the hunger of his heart. How prodigiously she carried her dusky little head! With what a gallant air she did all things! He was usually a . . . man, but when he was with her it seemed to him as God . . . throughout . . . mankind . . . ality—all sorts . . . brave, fine . . . tributes.

SHEBA paid . . . pledge in full. After the first . . . stanza . . . vanished, she sang the . . . ones . . .

An' what about the weather when
A'd have sold Pierre's boat?
Is't me that would be feared to
Grip the oars an' go afloat?
Oh, I could find me by the light
Of star or moon or star.
But there's caulder things than salt waves
Between us, so they are.
Och aree!

Sure, well I know he'll never have
The heart to come to me,
An' love is wild as any ave
That flashes on the sea.
'Tis the same if he is near me;
'Tis the same if he is far.
His thoughts are hard an' ever hard
Between us, so they are.
Och aree!

Her hands dropped from the keys, and she turned slowly on the end of the seat. The dark lashes fell to her hot cheeks. He did not speak, but she felt the steady insistence of his gaze. In self-defense she looked at him.

The pallor of his face lent accent to the fire that smoldered in his eyes.

"I'm going to marry you, Sheba. Make up your mind to that, girl," he said harshly.

There was infinite pity in the look she gave him. "There' cauldrr things than salt waves between us, so they are,' she quoted.

"Not if I love you and you love me. I'll trample down everything that comes between us."

She rose to a sitting position on the lounge. There . . . the steel-gray eyes in the brooding face his masterful spirit wrestled with . . . lean-limbed Samson, with a head, powerful shoulders and deep chest, he dominated his world ruthlessly. But the slim Irish girl held her own.

"Just what . . . through that again?" she asked gently.

"Again and again until you see reason."

She knew the tremendous driving power of the man, and she was afraid in her heart that he would sweep her from the moorings to which she clung. "There is something else I must tell you." She embarrassed flushes lifted bravely from the blushed cheeks to meet steadily his look. "I don't think that I—care for you. 'Tis I that am ashamed at my . . . coldness. But I don't—not . . . the full . . . my heart."

Figure 7.

deal with these electrically and cryptanalytically more complex forms of cryptology. We shall stick to enciphered or encrypted writing—which will be hard enough for most of us.

Writing may be either visible or invisible. In the former, the characters are inscribed with ordinary writing materials and can be seen with the naked eye; in the latter, the characters are inscribed by means or methods which make the writing invisible to the naked eye. Invisible writing can be prepared with certain chemicals called sympathetic or secret inks, and in order to "develop" such writing, that is, make it visible, special processes must usually be applied. Shown in Fig. 7 is an interesting example—the developed secret-ink message that figured in an $80,000,000 suit won by two American firms against the German Government after World War I sabotage was proved. There are also methods of producing writing which is invisible to the naked eye because the characters are of microscopic size, thus requiring special microscopic and photographic apparatus to enlarge such writing enough to make it visible to the naked eye. Here's an example—a code message in a space not much larger than the head

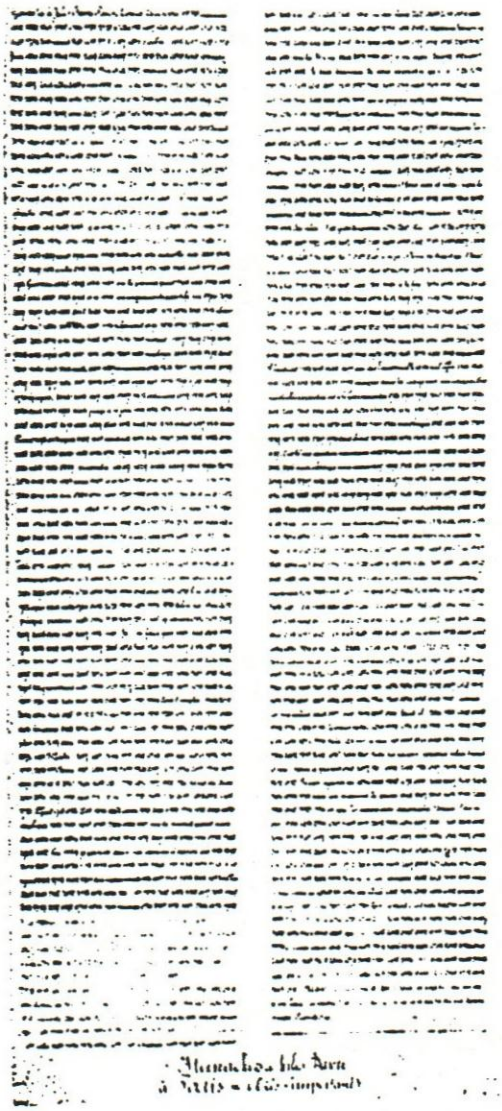


Figure 8.

of a pin. A simple definition of secret writing would be to say that it comprises invisible writing and unintelligible visible writing.

There is one additional piece of basic information which it is wise to call to your attention before we proceed much further, and I'll begin by stating that the greatest and the most powerful instrument or weapon ever forged and improved by man in his long struggle for emancipation from utter dependence upon his own environment is the weapon of literacy—a mastery of reading and writing; and the most important invention, the one that made the weapon of literacy *practical*, was the invention of the *alphabet*. It is therefore a rather striking anomaly that we should now come to the study of another weapon—a counter-weapon to the weapon of literacy—the weapon of *secrecy*, the basic intent of which is to thwart the weapon that man struggled so long to forge. Secrecy is applied to make writing more difficult and the reading of the writing very difficult, if not impossible.

Perhaps this is a good place to do a bit of theorizing about this matter of secrecy and what it implies.

Every person who enciphers a piece of writing, a message, or a text of any kind, for the purpose of hiding something or keeping something secret, does so with the idea that some other person, removed from him in distance, or time, or both, is intended to decipher the writing or message and thus uncover the secret which was so hidden. A person may possess a certain piece of knowledge which he does not wish to forget, but which he is nevertheless unwilling to commit to open writing, and therefore he may jot it down in cryptic form for himself to decipher later, when or if the information is needed. The most widely known example of such a cryptogram is found in Edgar Allan Poe's romantic tale *The Gold Bug*. That sort of usage of cryptography, however, is unusual. There are also examples of the use of cipher writing to establish priority of discovery, as did the astronomers Galileo and Huygens. I suppose I should at least mention another sort of cryptic writing famous in literary history, the diaries of persons such as Samuel Pepys and William Byrd. These are commonly regarded as being "in cipher," but they were actually written in a more-or-less private shorthand and can easily be read without the help of cryptanalysis. In Fig. 9 is shown a page of Pepys' diary.

Now there can be no logical reason, point, or purpose in taking the time and trouble to encipher anything unless it is expected that some other person is to decipher the cipher some time in the future. This means that there must exist some very direct, clear-cut and unambiguous relationship between the enciphering and deciphering operations. Just what such a relationship involves will be dealt with later, but at this moment all that it is necessary to say is that in enciphering there must be rules that govern or control the operations, that these rules must admit of no uncertainty or ambiguity, and that they must be susceptible of being applied with undeviating precision, since otherwise it will be difficult or perhaps impossible for the decipherer to obtain the correct answer when he reverses the processes or steps followed in the encipherment. This may be a good place to point out that a valid or authentic cryptanalytic solution cannot be considered as being merely what the cryptanalyst thinks or says he thinks the cryptogram means, nor does the solution represent an *opinion* of the cryptanalyst. Solutions are valid only insofar as they are objective and susceptible of demonstration or proof employing scientifically acceptable methods or procedures. It should hardly be necessary to indicate that the validity of the results achieved by cryptanalytic studies of authentic cryptograms rests upon the same sure and well established scientific foundations, and is reached by the same sort of logic as are the discoveries, results, or "answers" achieved by any other scientific studies, namely: observation, hypothesis, deduction, induction, and confirmatory experiment. Implied in what I have just said is the tacitly understood and now rarely explicitly stated assumption that two or more, equally competent and, if necessary, specially qualified investigators, each working independently upon the same material, will achieve identical or practically identical results.

Cryptology is usually and properly considered to be a branch of mathematics, although Francis Bacon considered it also a branch of grammar and what we now call linguistics. Math-

Figure 9.

ematical and statistical considerations play an ever-increasing and prominent role in practical cryptology, but don't let my statement of this point frighten those of you who have not had much formal instruction in these subjects. We have excellent cryptologists who have never studied more than arithmetic, and some of our best ones would hide if you were to go searching for mathematicians around here. What is needed is the ability to reason logically, as the mathematician sometimes does, and this ability is found in the most curious sorts of persons and places. So those of you who are frightened by the words mathematics and statistics take heart--you're not nearly so badly off as you may fear.

But now to return to the main theme, the place mathematics occupies in cryptology, let me say that just as the solution of mathematical problems leaves no room for the exercise of divination or other mysterious mental or psychic powers, so a valid solution to a cryptogram must leave no room for the exercise of such powers. In cryptologic science there is one and only one valid solution to a cryptogram, just as there is but one correct solution or "solution set" to any problem in mathematics. But perhaps I've already dwelt on this point too long; in any case, we'll come back to it later, when we come to look at certain types of what we may call pseudo-ciphers.

In the next lecture I'm going to give you a brief glimpse into the background or history of cryptology, which makes a long and interesting story that has never been told accurately and in detail. The history of communication security, that is, of cryptography, and the history of communication intelligence, that is, of cryptanalysis, which are but opposite faces of the same coin, deserve detailed treatment, but I am dubious that this sort of history will ever be written because of the curtain of secrecy and silence which officially surrounds the whole field of cryptology. *Authentic* information on the background and development of these vital matters having to do with the security of a nation is understandably quite sparse.

But in the succeeding lectures I'll try my best to give you authentic information, and where there's conjecture or doubt I'll so indicate. I must add, however, that in this series I'm going to have to omit many highly interesting episodes and bits of information, not only because these lectures are of low classification, but also because we won't and can't for security considerations, go beyond a certain period in cryptologic history. Nevertheless, I hope that you won't be disappointed and that you'll learn certain things of great interest and importance, things to remember if you wish to make cryptology your vocation in life.

Lecture II

As I said at the close of the preceding lecture, a bit of history is always useful in introducing a subject belonging to a special and not too well known field; therefore, I'll proceed with some historical information about cryptology, which, as you learned before, comprises two closely related sciences, namely, cryptography and cryptanalysis. I will repeat and emphasize that they are but opposite faces of the same valuable coin; progress in one inevitably leads to progress in the other, and to be efficient in cryptology you must know something about each of them.

Cryptography and cryptanalysis probably go back to the dawn of the invention and development of the art of writing itself. In fact, there is reason for speculating as to which came first—the invention of writing or the invention of cryptography; it's somewhat like the question as to which came first—the hen or the egg. It is possible that some phases of cryptography came before the art of writing had advanced very far.

I've mentioned the art of writing. As in the case of other seemingly simple questions, such as, "why is grass green?," when we are asked to define writing we can't find a very simple answer, just because the answer isn't at all simple. Yet, Breasted, the famous University of Chicago historian and Orientalist, once said: "The invention of writing and of a convenient system of records on paper has had a greater influence in uplifting the human race than any other intellectual achievement in the career of man." There has been, in my humble opinion, no greater invention in all history. The invention of writing formed the real beginning of civilization. As language distinguishes man from other animals, so writing distinguishes civilized man from barbarian. To put the matter briefly, writing exists only in a civilization and a civilization cannot exist without writing. Let me remind you that animals and insects do communicate—there's no question about that; but writing is a thing peculiar to and found only as a phenomenon in which man and no animal or insect engages, and let's never forget this fact. Mankind lived and functioned for an enormous number of centuries before writing was discovered and there is no doubt that writing was preceded by articulate speech for eons—but civilization began only when men got the idea of and invented the art of writing. So far as concerns Western or Occidental civilization, writing is, in essence, a means of representing the sounds of what we call speech or spoken language. Other systems of writing were and some still are handicapped by trying to represent things and ideas by pictures. I'm being a bit solemn about this great invention because I want to impress upon you what our studies in cryptology are really intended to do, namely, to defeat the basic or intended purpose of that great invention: instead of recording things and ideas for the *dissemination* of knowledge, we want and strive our utmost to pervent this aim from being realized, *except among our own brethren and under certain special circumstances*, for the purpose of our mutual security, our self-preservation. And that's important.

Writing is a comparatively new thing in the history of mankind. No complete system of writing was used before about 3500 B.C.

Ordinary writing, the sort of writing you and I use, is perhaps an outgrowth or development of picture writing or rebus writing, which I'm sure most of you enjoyed as children. A rebus contains features of both ordinary and cryptographic writing; you have to "decrypt" the significance of some of the symbols, combine single letters with syllables, pronounce the word that is represented by pictures, and so on. Fig. 10 is an example which I have through the courtesy of the Bell Telephone Laboratories. See how much of it you can make out in half a minute.

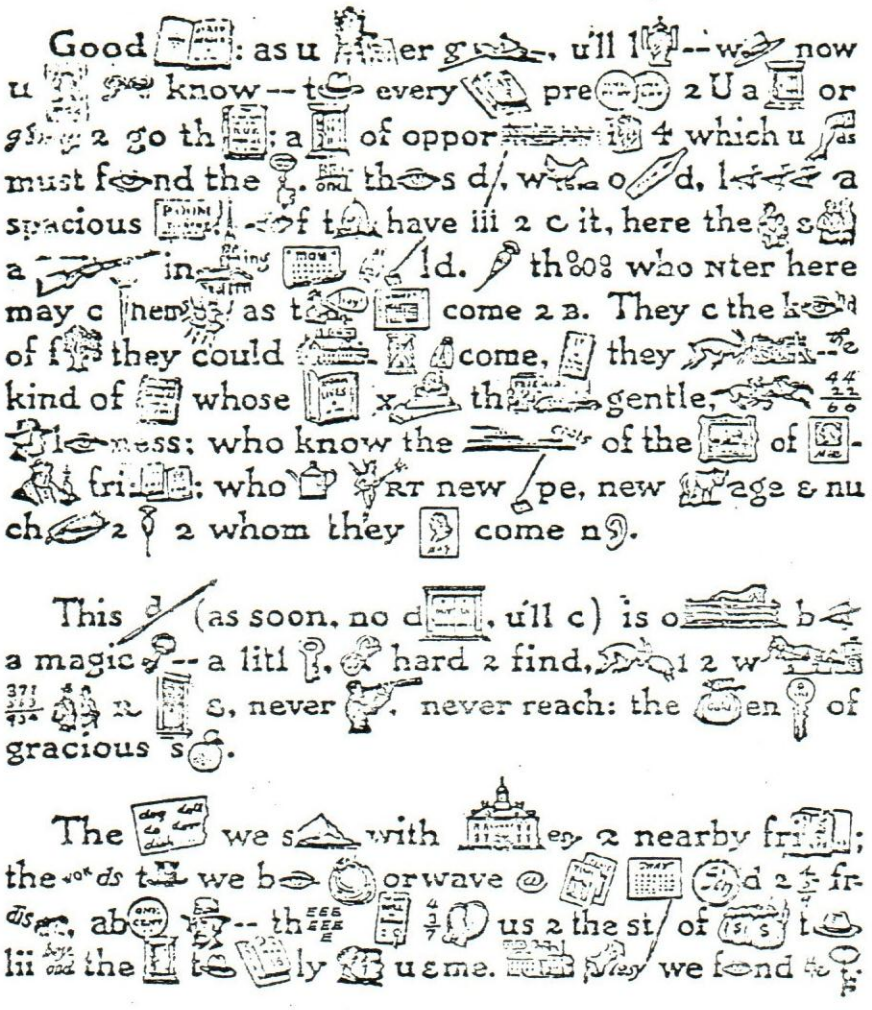


Figure 10.

From rebus writing there came in due course alphabetic writing and let me say right now that the invention of the alphabet, which apparently happened only once in the history of mankind, in some Middle East Semitic region, in or near the Palestine-Syria area, then spread throughout the whole of the European continent, and finally throughout most of the world, is Western man's greatest, most important, and most far-reaching invention because it forms the foundation of practically all our written and printed knowledge, except that in Chinese. The great achievement of the invention of the alphabet was certainly not the creation of the signs or symbols. It involved two brilliant ideas. The first was the idea of representing merely the *sounds* of speech by symbols, that is, the idea of what we may call *phoneticization*; the second was the idea of adopting a system in which, roughly speaking, each speech sound is denoted or represented by one and only one symbol. Simple as these two ideas seem to us *now*, the invention was apparently made, as I've said, only once and the inventor or inventors of the alphabet deserve to be ranked among the greatest benefactors of mankind. It made possible the recording of the memory of mankind in our libraries, and from that single invention have come all past and present alphabets. Some of the greatest of men's achievements we are now apt to take for granted; we seldom give them any thought. The invention of the art of writing and the invention of the alphabet are two such achievements and they are worth pondering upon. Where would we be without them? Note that among living languages Chinese pre-

sents special problems not only for the cryptologist but also for the Chinese themselves. No Sinologist knows all the 80,000 or so Chinese symbols, and it is also far from easy to master merely the 9,000 or so symbols actually employed by Chinese scholars. How far more simple it is to use only 20 to 26 symbols! Being a monosyllabic language, it seems almost hopeless to try to write Chinese by the sort of mechanism used in an alphabetic polysyllabic language; attempts along these lines have been unsuccessful and the difficulties in memorizing a great many Chinese characters account for the fact that even now only about 10% of the Chinese people can read or write to any significant degree. The spread of knowledge in China is thereby much hampered.

We find instances of ciphers in the Bible. In Jeremiah Chapter 25, Verse 26 occurs this expression: "And the King of Sheshakh shall drink after them." Also, again in Jeremiah 51: 41: "How is Sheshakh taken!" Well, for perhaps many years that name "Sheshakh" remained

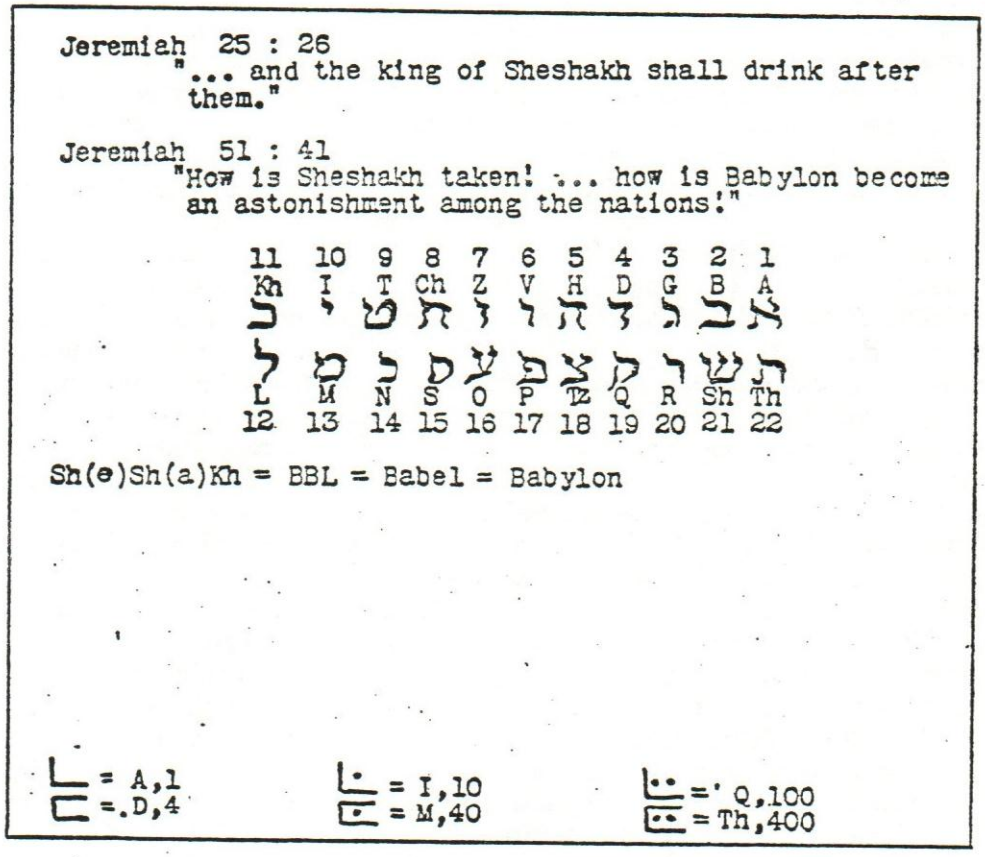


Figure 11.

a mystery, because no such place was known to geographers or historians. But then it was discovered that if you write the twenty-two letters of the Hebrew alphabet in two rows, eleven in one row and eleven in the other, as in Fig. 11, you set up a substitution alphabet whereby you can replace letters by those standing opposite them. For example, "shin," is represented by "beth" or vice versa, so that "Sheshakh" translates "Babel," which is the old name of "Babylon." Hebrew then did not have and still doesn't have vowels; they must be supplied. This is an example of what is called ATHBASH writing, that is, where Aleph, the first letter is replaced by Teth, the last letter; Beth, the second letter, by Shin, the next-to-the-last, etc. By sliding the second row of letters one letter each time there are eleven different cipher alphabets available for use. The old Talmudists went in for cryptography to a considerable extent.

Incidentally, in mentioning the Bible, I will add that Daniel, who, after Joseph in Genesis, was an early interpreter of dreams and therefore one of the first psychoanalysts, was also the first cryptanalyst. I say that he was an early psychoanalyst, because you will remember that he interpreted Nebuchadnezzar's dreams. In the Bible's own words, "Nebuchadnezzar dreamed dreams, wherewith his spirit was troubled, and sleep brake from him." But, unfortunately, when he woke up he just couldn't remember those troublesome dreams. One morning he called for his wise men, magicians, astrologers, and Chaldean sorcerers and asked them to interpret the dream he'd had during the preceding night. "Well, now, tell us the dream and we'll try to interpret it," they said. To which King Nebuchadnezzar exclaimed, "The thing is gone from me. I don't remember it. But it's part of your job to find that out, too, and interpret it. And if you can't tell me what the dream was, and interpret it, things will happen to you." What the king asked was a pretty stiff assignment, of course, and it's no wonder they failed to make good, which irked Nebuchadnezzar no end. Kings had a nasty habit of chopping your head off in those days if you failed or made a mistake, just as certain arbitrary and armed despots are apt to do even in modern times for more minor infractions, such as not following the Party Line. So in this case it comes as no surprise to learn that Nebuchadnezzar passed the word along to destroy *all* the wise men of Babylon, among whom was one of the wise men of Israel, named Daniel. Well, when the King's guard came to fetch him, Daniel begged that he be given just a bit more time. Then, by some act of divination,—the Bible simply says that the secret was revealed to Daniel in a night vision—Daniel was able to reconstruct the dream and then to interpret it. Daniel's reputation was made. Some years later, Nebuchadnezzar's son Belshazzar was giving a feast, and, during the course of the feast, in the words of the Bible, "came forth fingers of a man's hand and wrote over against the candlestick upon the plaster of the wall." The hand wrote a secret message. You can imagine the spine-chilling scene. Belshazzar was very much upset, and just as his father did, he called for his wise men, soothsayers, Chaldean sorcerers, magicians and so on, but they couldn't read the message. Apparently they couldn't even read the cipher characters! Well, Belshazzar's queen fortunately remembered what that Israelite Daniel had done years before, and she suggested that Daniel be called in as a consultant. Daniel was called in by Belshazzar, and he succeeded in doing two things. He succeeded not only in *reading* the writing on the wall: "MENE, MENE, TEKEL, UPHARSIN," but also he was successful in deciphering the meaning of those strange words. His interpretation: "Mene" — "God hath numbered thy kingdom and finished it." "Tekel" — "Thou are weighed in the balances and found wanting." "Upharsin" — "Thy kingdom shall be divided and given to the Medes and Persians." Apparently the chap who did the handwriting on the wall knew a thing or two about cryptography, because he used what we call "variants," or different values, for in one case the last word in the secret writing on the wall is "Upharsin" and in the other it is "Peres"; the commentators are a bit vague as to why there are these two versions of the word in the Bible. At any rate, Babylon was finished, just as the inscription prophesied; it died with Belshazzar. I think this curious Biblical case of the use of cryptography is interesting because I don't think anybody has really found the true meaning of the sentence in secret writing, or explained why the writing on the wall was unintelligible to all of Belshazzar's wise men.

Probably the earliest reliable information on the use of cryptography in connection with an alphabetic language dates from about 900 B.C., Plutarch mentioning that from the time of Lycurgus there was in use among the Lacedemonians, or ancient Spartans, a device called the *scytale*. This device, which I'll explain in a moment, was definitely known to have been used in the time of Lysander, which would place it about 400 B.C. This is about the time that Aeneas Tacticus wrote his large treatise on the defense of fortification, in which there is a chapter devoted specifically to cryptography. In addition to mentioning ways of physically concealing messages, a peculiar sort of cipher disk is described. Also a method of replacing words and letters by dots is mentioned.

Figure 12 is a picture of the scytale, one of the earliest cipher devices history records. The scytale was a wooden cylinder of specific dimensions around which they wrapped spirally a

piece of parchment or leather; they then wrote the message on the parchment, unwound it, and sent it to its destination by a safe courier, who handed it over to the commander for whom it was intended and who, having been provided with an identically dimensioned cylinder, would wind the strip of leather or parchment around his cylinder and thus bring together properly the letters representing the message. This diagram may not be accurate. I don't think anyone really understands the scheme. The writing was done across the edges of the parchment, according to some accounts, and not between the edges, as shown here. Incidentally, you may be interested to learn that the baton which the European field marshal still carries as one of the insignia of his high office derives from this very instrument.

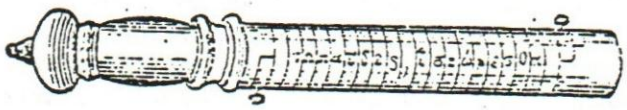


Figure 12.

We don't know much about the use of cryptography by the Romans, but it is well known that Caesar used an obviously simple method; all he did was to replace each letter by the one that was fourth from it in the alphabet. For example, *A* would be represented by *D*, *B* by *E* and so on. Augustus Caesar is said to have used the same sort of thing, only even more simple: each letter was replaced by the one that followed it in the alphabet. Cicero was one of the inventors of what is now called shorthand. He had a slave by the name of Tiro, who wrote Cicero's records in what are called Tironian notes. Modern shorthand is a development of Tiro's notation system.

In Fig. 13 we see some cipher alphabets of olden times, alphabets used by certain historical figures you'll all remember. The first cipher alphabet in this figure was employed by Charlemagne, who reigned from 768 to 814 A.D. The second one was used in England during the reign of Alfred the Great, 871 to 899. The third alphabet is called *ogam writing* and was used in ancient Ireland. The alphabets below that were used much later in England: the fourth one by Charles the First, in 1646; the fifth, the so-called "clock cipher," was used by the Marquis of Worcester in the 17th Century; finally, the last one was used by Cardinal Wolsey in about 1524.

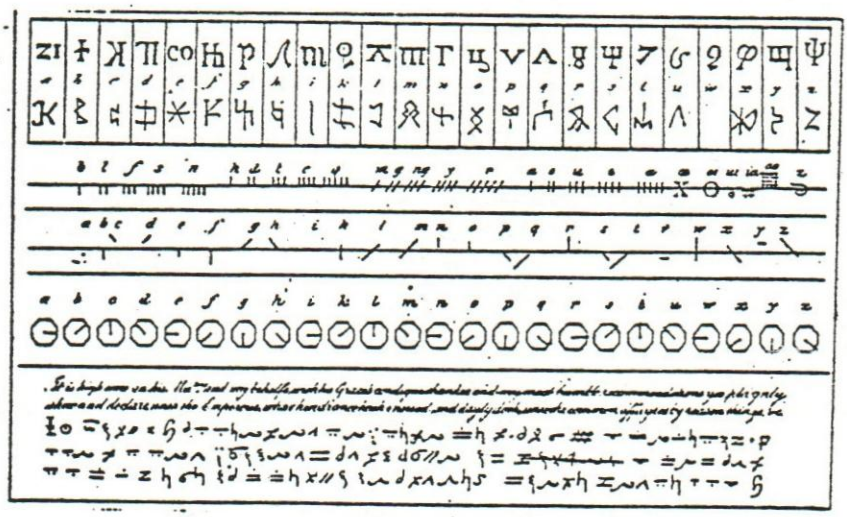


Figure 13.

In the Middle Ages cryptography appears first as a method of concealing proper names, usually by the simple substitution of each letter by the next one in the alphabet, just about as Augustus Caesar did hundreds of years before. At other times the vowels were replaced by dots, without changing the consonants—a method that was used throughout Europe to about 1000 A.D., when letters began to be replaced by various signs, by other letters, by letters from another language, by runes which are found in abundance in Scandinavia, and by arbitrary symbols. Figure 14 is an example of a runic inscription on a stone that stands before Gripsholm Castle near Stockholm, Sweden. The word rune means "secret."

Within a couple of hundred years the outlines of modern cryptography began to be formed by the secret correspondence systems employed by the small Papal States in Italy. In fact, the real beginnings of systematic, modern cryptology can be traced back to the days of the early years of the 13th Century, when the science began to be extensively employed by the princes and chanceries of the Papal States in their diplomatic relations amongst themselves and with other countries in Europe. The necessity for secret communication was first met by attempts inspired by or derived from ancient cryptography, as I've outlined so far. There was a special predilection for vowel substitution but there appeared about this time one of the elements which was later to play a very prominent role in all cipher systems, an element we now call a *syllabary*, or a *repertory*. These were lists of letters, syllables, frequently used parts of speech and words, with additions of arbitrary equivalents for the names of persons and places. There is still in existence one such syllabary and list of arbitrary equivalents which was used about 1236 A.D., and there are other examples that were used in Venice in 1350.

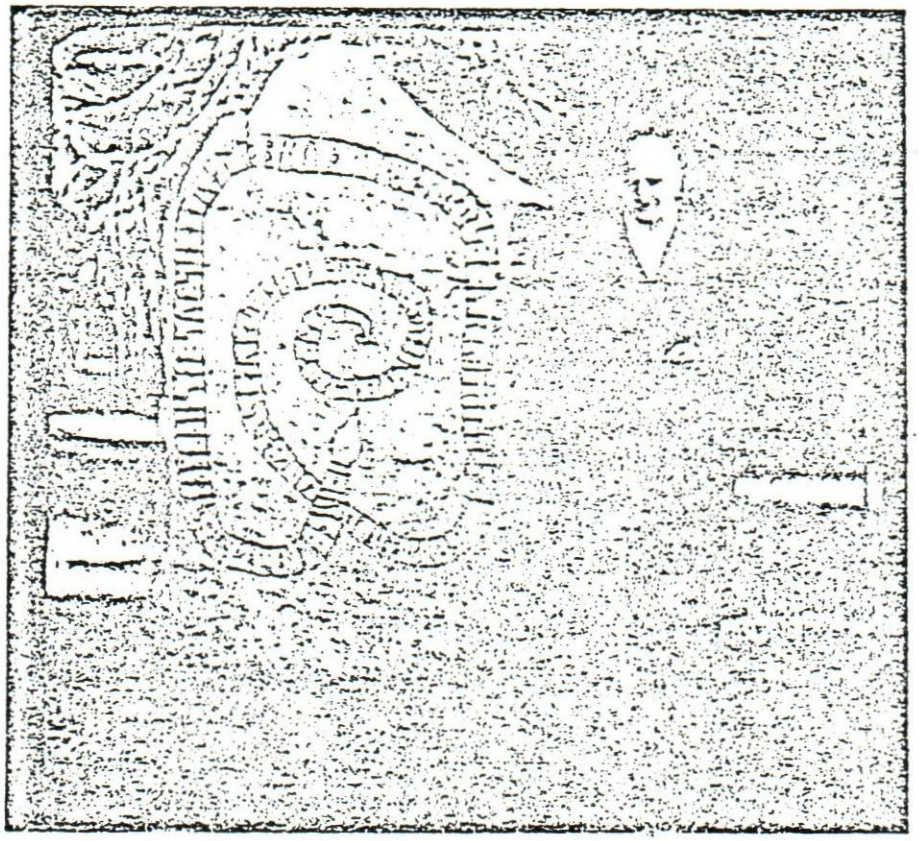


Figure 14.—A Couple of Old Ruins.

Among examples of ciphers in medieval cryptography is a collection of letters of the Archbishop of Naples, written between 1363 and 1365, in which he begins merely with symbol substitutions for the vowels and uses the letters that are actually vowels to serve as nulls or non-significant letters to throw the would-be-cryptanalyst off the right track. As a final development, the high-frequency consonants *L*, *M*, *N*, *R*, and *S*, and all the vowels, are replaced not only by arbitrary symbols but also by other letters.

About 1378 an experienced cryptologist named Gabriele Lavinde of Parma was employed as a professional by Clement VII and in the Vatican Library there is a collection of ciphers devised and used by Lavinde about 1379. It consists of repertories in which every letter is replaced by an arbitrary symbol. Some of these ciphers also have nulls and arbitrary equivalents or signs for the names of persons and places. There is a court cipher of Mantua, dated 1395, that used this system.

At the beginning of the 15th Century the necessity of having variants for the high-frequency letters, especially the vowels, became obvious. Figure 15 is an alphabet of that period which is interesting because it shows that even in those early days of cryptology there was already a

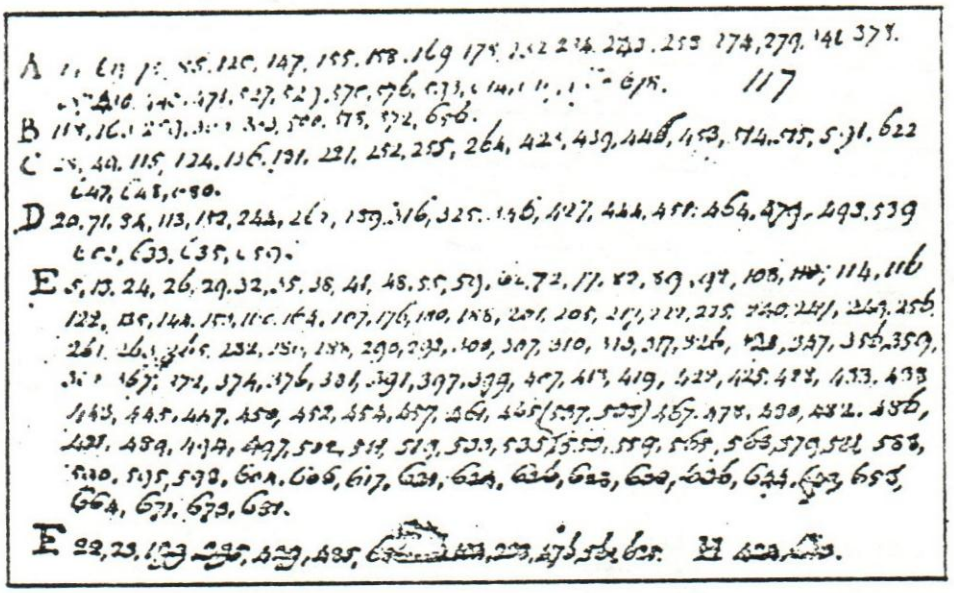


Figure 15.

recognition of the basic weakness of what we call single or monoalphabetic substitution, that is, where every letter in the plaintext message is represented by another and always the same letter. Solution of this type of cipher, as many of you may know, is accomplished by taking advantage of the fact that the letters of an alphabetic language are used with greatly differing frequencies. I don't have to go into that now because many of you, at some time or other, have read Edgar Allan Poe's "Gold Bug," and understand the principles of that sort of analysis. It is clearly shown in the figure that the early Italian cryptographers understood the fact of varying frequencies and introduced stumbling blocks to quick and easy solution by having the high-frequency letters represented by more than a single character, or by several characters, as you can see. I will add that the earliest tract that the world possesses on the subject of cryptography, or for that matter, cryptanalysis, is that which was written in 1474 by a Neapolitan, whose name was Sicco Simonetta. He set forth the basic principles and methods of solving ciphers, simple ciphers no doubt, but he describes them and their solution in a very clear and concise form.

Cipher systems of the type I've described continued to be improved. In Fig. 16 is shown what we may call the first complete cipher system of this sort. There are substitution symbols

for each letter; the vowels have several equivalents; there are nulls; and there is a small list of arbitrary symbols, such as those for "the Pope," the word "and," the conjunction "with," and so on. This cipher, dated 1411, was used in Venice, and is typical of the ciphers used by the Papal chanceries of those days.

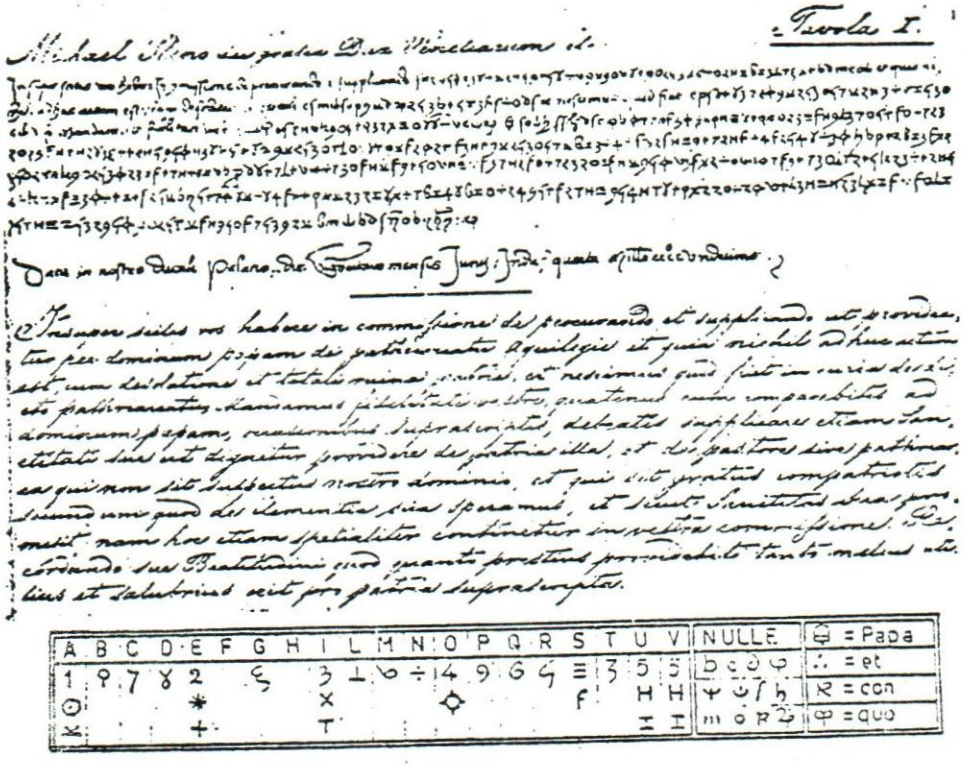


Figure 16.

The step remaining to be taken in the development of these ciphers was to expand the "vocabulary," that is, the list of equivalents for frequently used words and syllables, the names of persons and places, parts of speech, and so on. This step was reached in Italy during the first half of the 15th Century and became the prototype of diplomatic ciphers used in practically all the states of Europe for several centuries. One of 70 ciphers collected in a Vatican codex and used from about 1440 to 1469 is shown in Fig. 17. Note that the equivalents of the plaintext items are Latin words and combinations of two and three letters, and that they are listed in an order that is somewhat alphabetical but not strictly so. I suppose that by constant use the cipher clerks would learn the equivalents almost by heart, so that an adherence to a strict alphabetic sequence either for the plaintext items or for their cipher equivalents didn't hamper their operations too much. In Fig. 18 there is much the same sort of arrangement, except that now the cipher equivalents seem to be digraphs, and these are arranged in a rather systematic order for ease in enciphering and deciphering. Now we have the real beginnings of what we call a one-part code, that is, the same list will serve both for encoding and decoding. These systems, as I've said, remained the prototypes of the cryptography employed throughout the whole of Europe for some centuries. The Papal States used them, and as late as 1793 we find them used in France. I wish here to mention specifically the so-called King's General Cipher used in 1562 by the Spanish Court. It is shown in Fig. 19.

But there were two exceptional cases which show that the rigidity of cryptographic thought as now and then broken during the four centuries we have been talking about in this brief historical survey. Some of the Papal ciphers of the 16th Century and those of the French

Court under Kings Louis XIII and XIV exemplify these exceptions. In the case of these French Court ciphers we find that a French cryptologist named Antonio Rossignol, who was employed by Cardinal Richelieu, understood quite well the weaknesses of the one-part code and syllabaries. It was he who, in about 1640, introduced a new and important improvement, the idea of the two-part code or syllabary, in which for encoding a message the items in the vocabulary are listed in some systematic order, nearly always alphabetical; the code equivalents, whatever they may be, are assigned to the alphabetically listed items in random order. This means that there must be another arrangement or book for ease in decoding, in which the code

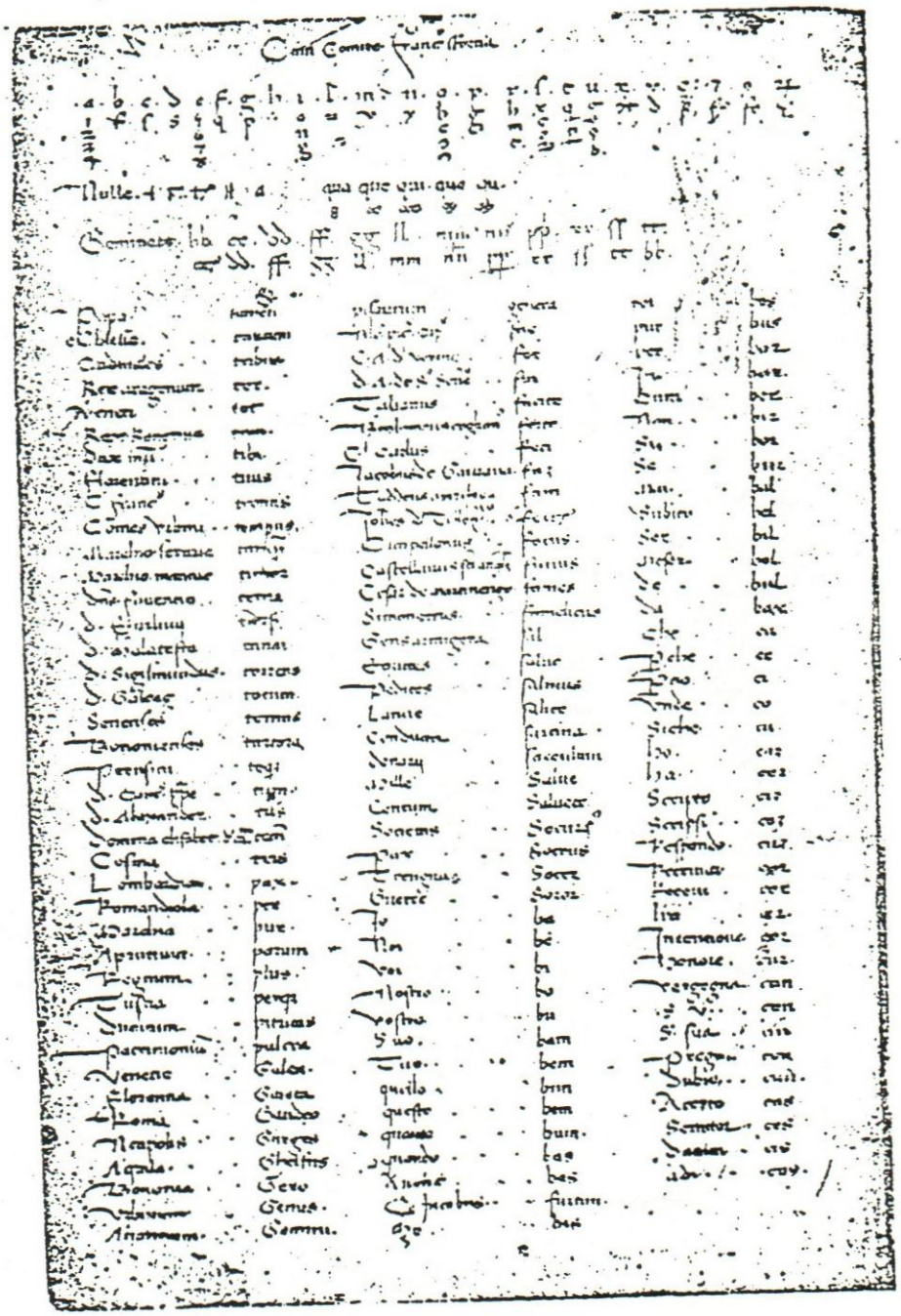


Figure 17.

equivalents are listed in systematic order, numerically or alphabetically as the case may be, and alongside each appears its meaning in the encoding arrangement, or book. The significance of this improvement you'll find out sooner or later. Codes of this sort also had variants—Rossignol was clever, indeed. One such code, found in the 1691 correspondence of Louis XIV had about 600 items, with code groups of two and three digits. Not at all bad, for those days!

Now this sort of system would appear to be quite secure, and I suppose it was indeed so, for those early days of cryptographic development—but it wasn't proof against the cleverness

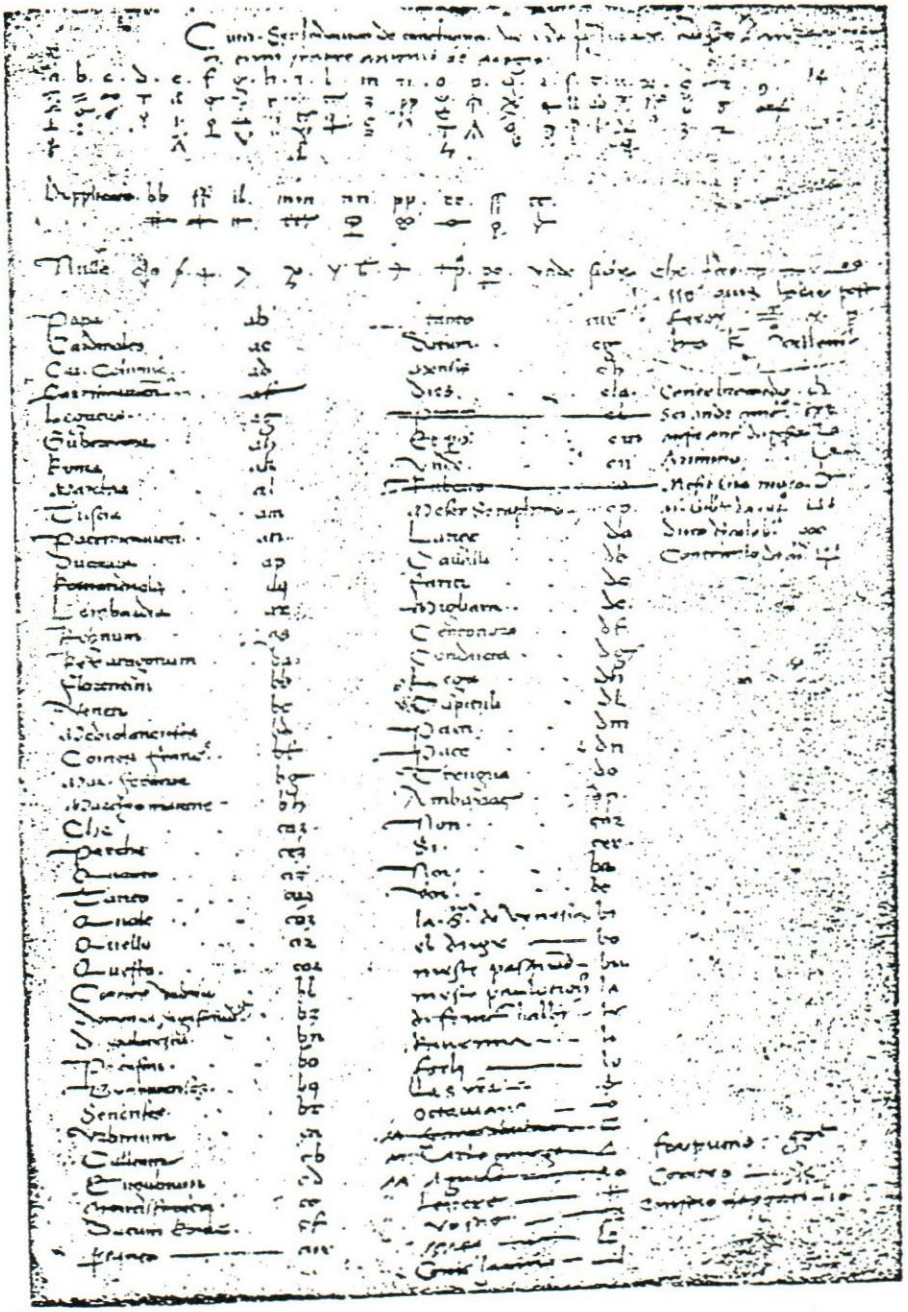
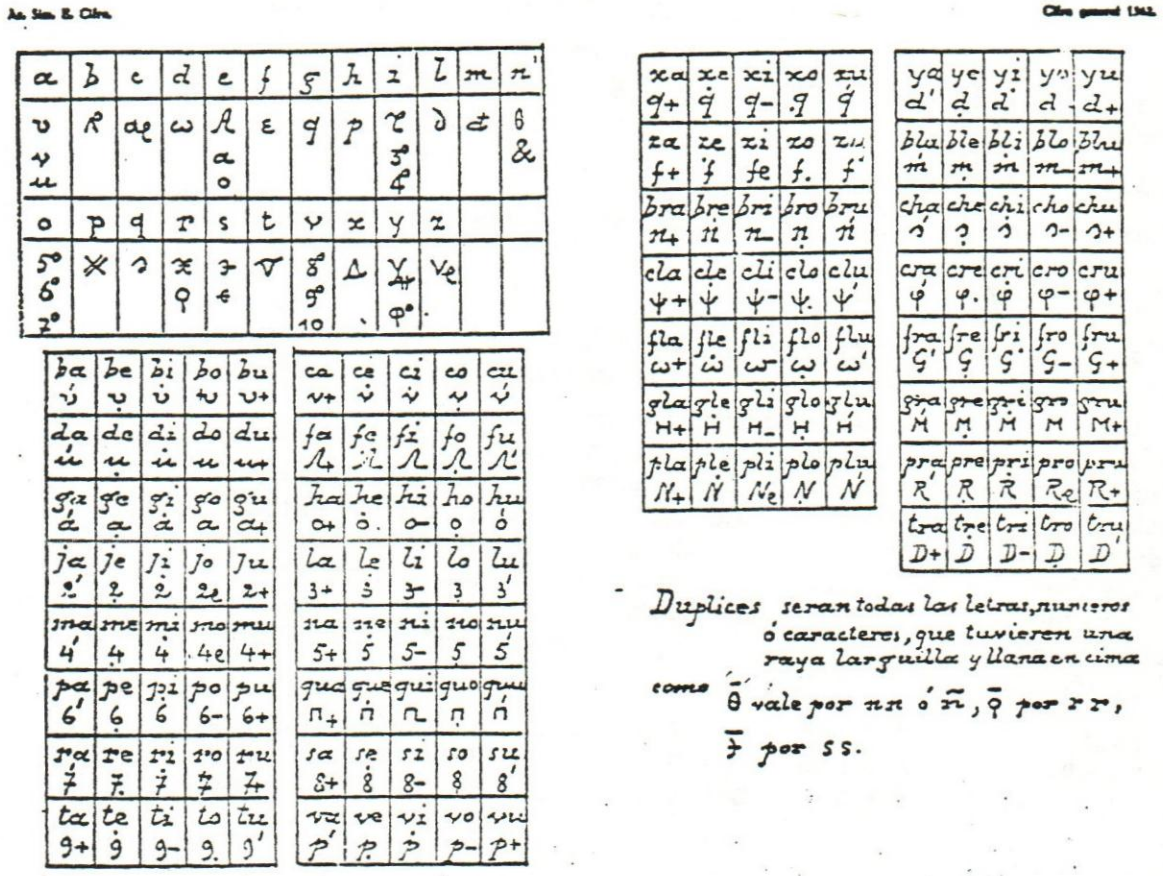


Figure 18.



Duplices seran todas las letras, numeros ó caracteres, que tuvieren una raya larguilla y llana en cima como $\bar{\theta}$ vale por nn ó $\bar{n}$, $\bar{\varphi}$ por rr, $\bar{7}$ por ss.

Figure 19.

of British brains, for the eminent mathematician John Wallis solved messages in it in 1689. Never underestimate the British in this science—as we'll have reason to note in another lecture in this series.*

French cryptography under Kings Louis XV and XVI declined, reaching perhaps its lowest level under Napoleon the Great. It is a fact that in Napoleon's Russian enterprise the whole of his army used but a single code book of only 200 groups, practically without variants, even for the high-frequency letters. Furthermore, not all the words in a message were encoded—only those which the code clerk or the writer of the message thought were important. It's pretty clear that the Russians intercepted and read many of Napoleon's messages—this comes from categorical statements to this effect by Czar Alexander I himself. We won't be far wrong in believing that the weaknesses of Napoleon's crypto-communications formed an important factor in Napoleon's disaster. A hundred and twenty-five years later, Russian ineptitude in cryptographic communications lost them the Battle of Tannenberg and eventually knocked them out of World War I.

The other 16th Century Papal ciphers that constituted the second exception to the general similarity of cryptographic systems of those days were quite different from those I've shown you. In this exception the ciphers were monoalphabetic, but some letters had the same equivalent, so that on decipherment the context had to be used to decide which of two or more possible plaintext values was the one meant by each cipher letter. One such cipher used by the Maltese Inquisitor in 1585 is shown below: You'll note that the digit 9 has two values, *A* and

* Official deciphering of foreign communications by British cryptanalysts can be traced back to about the year 1525, if not earlier.

CIPHER OF THE INQUISITOR OF MALTA (1585)
(From SACCO, MANUALE DI CRITTOGRAFIA, 1947)

Plain:	A,T	E,F	I,G	O,D	U,V,B	C,L,N	M,R	P,S,Z
Cipher:	ø	3	5	4	2	6	9	7

Nulls: 1,8

Plain:	qua	que	qui	quo	che	chi	non	quando	perchè	et per
Cipher:	7	9	6	2	4	5	3	ø	1,8	

7; the digit 2 has three values, *U*, *V*, and *B*, and so on. There were two digits used as nulls, 1 and 8; digits with dots above them stood for words such as *qua*, *que*, *qui*, and so on.

Below is shown a message and its encipherment: A bit tricky, isn't it? Many, many years later Edgar Allan Poe describes a cipher of this same general type, where the decipherer must choose between two or more possible plaintext equivalents in building up his plain text, the latter guiding the choice of the right equivalent. The trouble with this sort of cipher is that you have to have pretty smart cipher clerks to operate it and even then I imagine that in many places there would be doubtful decipherments of words. It wasn't really a practical system even in those days, but it could, if used skillfully and with only a small amount of text, give a cryptanalyst plenty of headaches. But such systems didn't last very long because of the practical difficulties in using them.

Cipher:	4	5	1	ø	2	ø	4	1	4	ø	9	4	8	9	5	6	2	ø	4	1	ø	2	5	7	4
"Plain":	0	I		A	U	A	0		0	A	M	0		M	I	C	U	A	0		A	U	I	P	0
	D	G		T	B	T	D		D	T	R	D		R	G	L	B	T	D		T	B	G	S	D
					V											N	V					V		Z	
Plain:	D	I		T	U	T	0		D	A	R	0		M	I	N	U	T	0		A	V	I	S	0

Cipher:	1				4	5	6	5	1	6	4	9	5	3	9	3	8								
"Plain":	ET				0	I	C	I		C	0	M	I	E	M	E									
	PER				D	G	L	G		N	D	R	G	F	R	F									
	PERCHÈ						N			L															
Plain:	PER				0	G	N	I		C	0	R	I	E	R	E									

The first regular or official cipher bureau in the Vatican was established in about 1540 and in Venice at about the same time, about one hundred years before a regular cipher bureau was established in France by Cardinal Richelieu. It is interesting to observe that no new or remarkable ideas for cryptosystems were developed for a couple of hundred years after the complex ones I've described as having been developed by the various Papal cryptologists. One-part and two-part syllabaries and simple or complex ones with variants were in use for many decades, but later on, in a few cases, the code equivalents were superenciphered, that is, the code groups formed the text for the application of a cipher, generally by rather simple systems of additives. Governmental codes were of the two-part type and were superenciphered by the more sophisticated countries.

The first book or extensive treatise on cryptography is that by a German abbot named Trithemius, who published in 1531 the first volume of a planned monumental 4-volume work. I said that he planned to publish four volumes; but he gave up after the third one, because he wrote so obscurely and made such fantastic claims that he was charged with being in league with the Devil, which was a rather dangerous association in those or even in these days. They didn't burn Trithemius but they did burn his books. Figure 20 illustrates that the necessity for secrecy in this business was recognized from the very earliest days of cryptology, and cer-

tainly by Trithemius. Here is the sort of oath that Trithemius recommended be administered to students in the science of cryptology. All of you have subscribed to a somewhat similar oath, but we now go further and back up the oath with a rather strict law. You've all read it, I'm sure.

The Trithemian Oath
given by
Johannes Trithemius
in
Book II, Chapter XXIV, of his "Steganographia".

I, ---(present name)---, by the Virtue of Almighty God, by the Blood of our Lord Jesus Christ, by the Resurrection of the Dead and the last Judgment, and by the Salvation of my Soul in the Holy Catholic Faith, swear to Almighty God, to the Blessed Virgin Mary, to all the Saints, and to you ---(receiver's name)---, that I will faithfully guard this Art of Steganography all the Days of my Life. I will teach it to no one without your Consent and Permission. Moreover I likewise swear and promise that I will not use this Knowledge in Opposition to God and his Commandments, not in Opposition to the Holy Roman Catholic Church and its Ministers.

So may God help me, and so may he save me at the last Judgment.

Figure 20.

We come now to some examples from more recent history. In Fig. 21 we see a cipher alphabet used by Mary, Queen of Scots, who reigned from 1542 to 1567 and was beheaded in 1587. In this connection it may interest you to learn that question has been raised as to whether the Queen was "framed" by means of this forged postscript (Fig. 22) in a cipher that was known to have been used by her.

The Spanish Court under Philip II, in the years 1555–1598, used a great many ciphers and here's one of them (Fig. 23). You see that it is quite complex for those early days and yet ciphers of this sort were solved by an eminent French mathematician named Vieta, the father modern algebra. In 1589 he became a Councelor of Parliament at Tours and then Privy Councillor. While in that job he solved a Spanish cipher system using more than 500 characters, so that all the Spanish dispatches falling into French hands were easily read. Philip was so convinced of the security of his ciphers that when he found the French were aware of the contents of his cipher dispatches to the Netherlands, he complained to the Pope that the French were using sorcery against him. Vieta was called on the carpet and forced to explain how he'd solved the ciphers in order to avoid being convicted of sorcery, a serious offense.

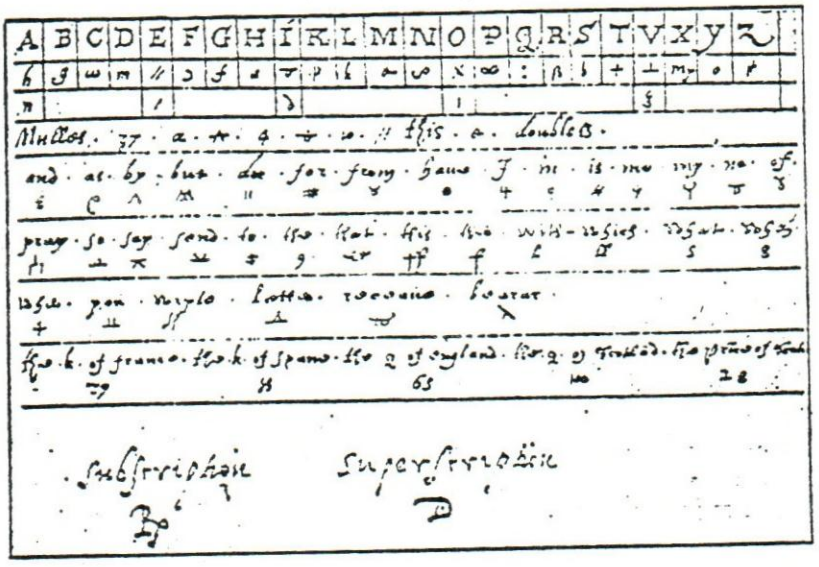
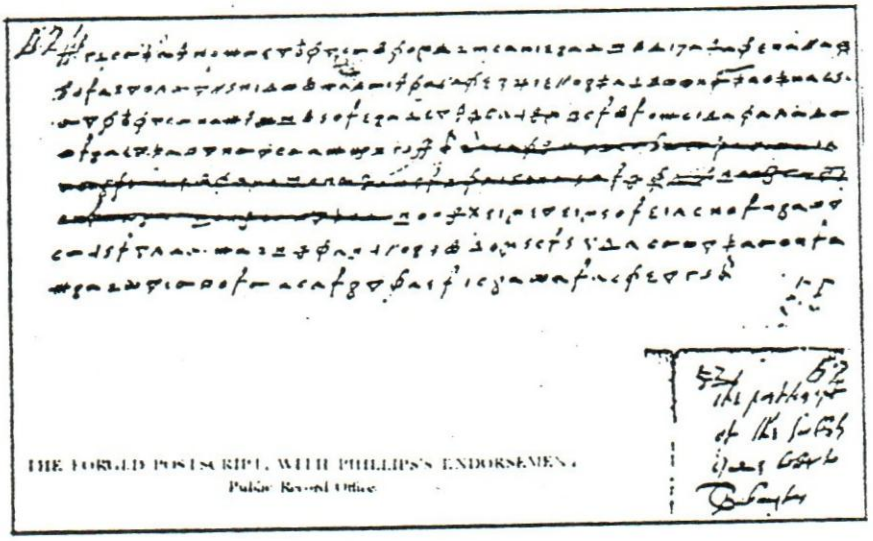


Figure 21.



THE FORGED POSTSCRIPT, WITH PHILLIPS'S ENDORSEMENT
Public Record Office

Figure 22.

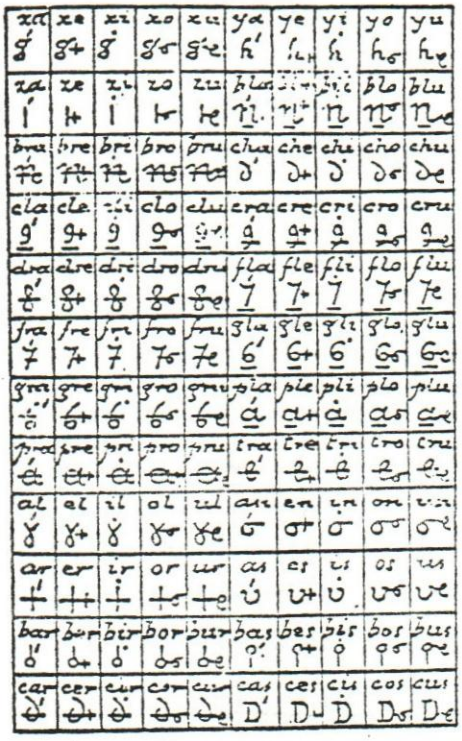


Figure 23.

A B	a	b	c	d	e	f	g	h	i	l	m
	n	o	p	q	r	s	t	v	x	y	z
C D	a	b	c	d	e	f	g	h	i	l	m
	z	n	o	p	q	r	s	t	v	x	y
E F	a	b	c	d	e	f	g	h	i	l	m
	y	z	n	o	p	q	r	s	t	v	x
G H	a	b	c	d	e	f	g	h	i	l	m
	x	y	z	n	o	p	q	r	s	t	v
I L	a	b	c	d	e	f	g	h	i	l	m
	v	x	y	z	n	o	p	q	r	s	t
M N	a	b	c	d	e	f	g	h	i	l	m
	t	v	x	y	z	n	o	p	q	r	s
O P	a	b	c	d	e	f	g	h	i	l	m
	s	t	v	x	y	z	n	o	p	q	r
Q R	a	b	c	d	e	f	g	h	i	l	m
	r	s	t	v	x	y	z	n	o	p	q
S T	a	b	c	d	e	f	g	h	i	l	m
	q	r	s	t	v	x	y	z	n	o	p
V X	a	b	c	d	e	f	g	h	i	l	m
	p	q	r	s	t	v	x	y	z	n	o
Y Z	a	b	c	d	e	f	g	h	i	l	m
	o	p	q	r	s	t	v	x	y	z	n

Figure 24.

The next cryptologist I want you to know something about is another Italian savant who wrote a book, published in 1563, in which he showed certain types of cipher alphabets that have come down in history and are famous as Porta's Alphabets. Figure 24 is an example of the Porta Table, showing one alphabet with key letters *A* or *B*, another alphabet with key letters *C* or *D*, and so on.

That Porta's table was actually used in official correspondence is shown by Fig. 25, which is a picture of a table found among the state papers of Queen Elizabeth's time; it was used for communicating with the English Ambassador to Spain. Porta was, in my opinion, the greatest of the old writers on cryptology. I also think he was one of the early, but by no means the first, cryptanalyst able to solve a system of keyed substitution, that is, where the key is changing consistently as the message undergoes encipherment. Incidentally, Porta also was the inventor of the photographic camera, the progenitor of which was known as the *camera obscura*.

Figure 26 is a picture of what cryptographers usually call the Vigenère Square, the Vigenère Table, or the Vigenère Tableau. It consists of a set of twenty-six alphabets successively displaced one letter per row, with the plaintext letters at the top of the square, the key letters at the side, and the cipher letters inside. The method of using the table is to agree upon a key word, which causes the equivalents of the plaintext letters to change as the key changes. Vigenère is commonly credited with having invented that square and cipher, but he really didn't and, what's more, never said he did. His table, as it appears in his book, the first edition of which was published in 1586, is shown in Fig. 27. It is more complicated than as described in ordinary books on cryptology.

Figure 28 is one more example of another old official cipher. In it we can see the alphabets which could be slid up and down, as a means of changing the key. Another early official cipher is shown in Fig. 29. It is a facsimile of a state cipher used in Charles the First's time, in 1627,

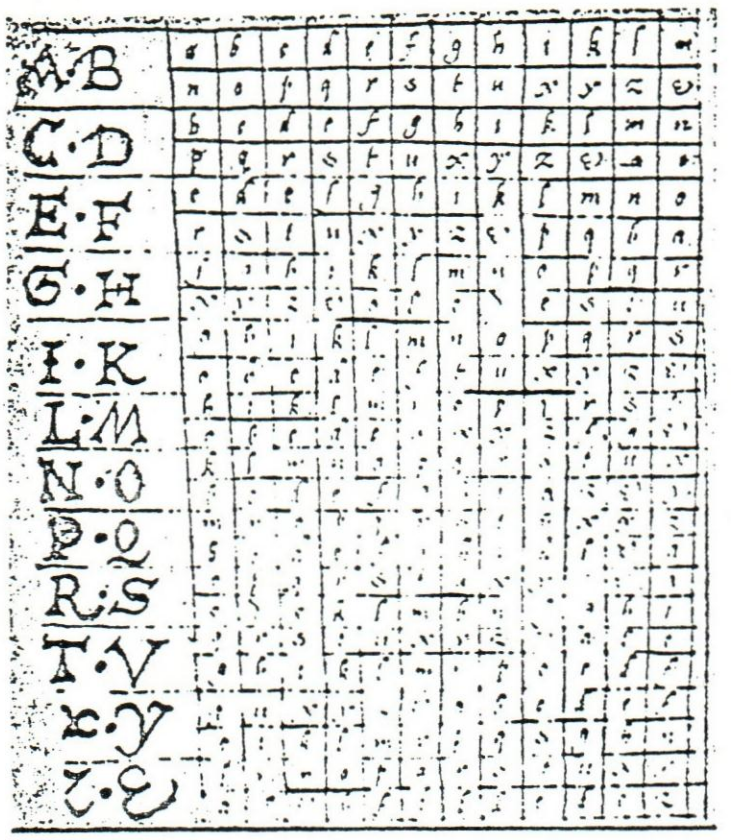


Figure 25.

for communicating with France and Flanders. It involves coordinates, and I want you to notice that there are two complete alphabets inside it, intended to smooth out frequencies. The letters of the key words OPTIMUS and DOMINUS serve as the coordinates used to represent the letters inside the square. A third old cipher, one used by George III in 1799, is shown in Fig. 30.

One writer deserving special attention as a knowledgeable cryptologist in the 17th Century, and the one with whose cipher I'll close this lecture, is Sir Francis Bacon, who invented a very useful cipher and mentioned it for the first time in his *Advancement of Learning*, published in 1604, in London. The description is so brief that I doubt whether many persons understood what he was driving at. But Bacon described it in full detail, with examples, in his great book *De Augmentis Scientiarum*, which was published almost 20 years later, in 1623, and which first appeard in an English translation by Gilbert Wats in 1640 under the title *The Advancement of Learning.* Bacon called his invention the *Biliteral Cipher*, and it is so ingenious that I think you should be told about it so that you will all fully understand it.

In his *De Augmentis* Bacon writes briefly about ciphers in general and says that the virtues required in them are three: "that they be easy and not laborious to write; that they be safe, and impossible to be deciphered without the key; and lastly, that they be, if possible, such as not to raise suspicion or to elude inquiry." He then goes on to say: "But for avoiding suspicion altogether, I will add another contrivance, which I devised myself when I was at Paris in my arly youth, and which I still think worthy of preservation." Mind you, this was 40 years later! Let's consult Bacon for further details. In Fig. 31 we see a couple of pages of the Gilbert Wat's translation of Bacon's *De Augmentis Scientiarum.* Bacon shows what he calls

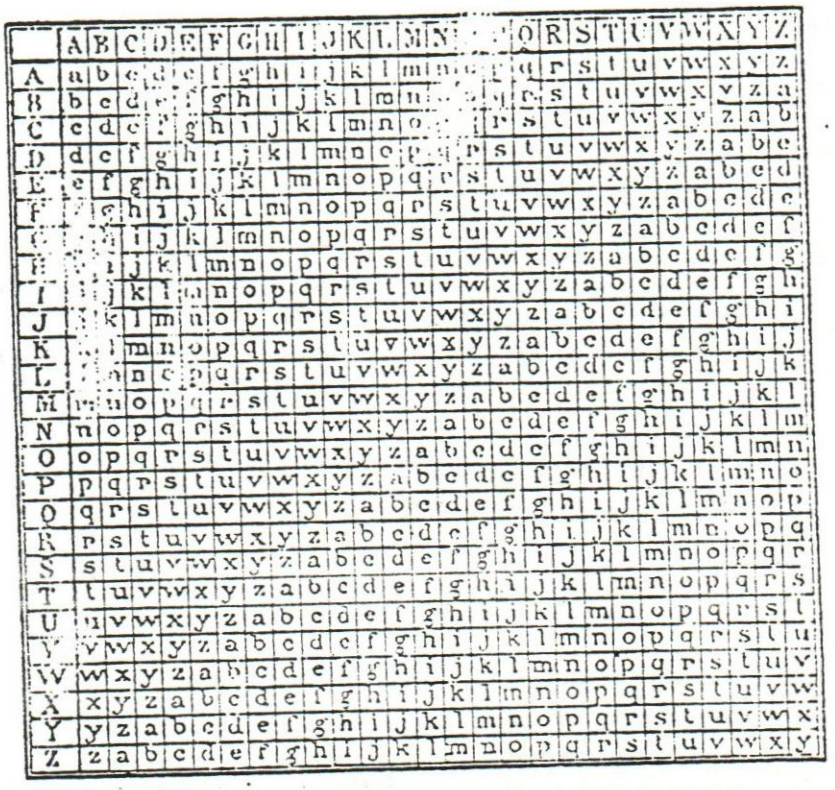


Figure 26.

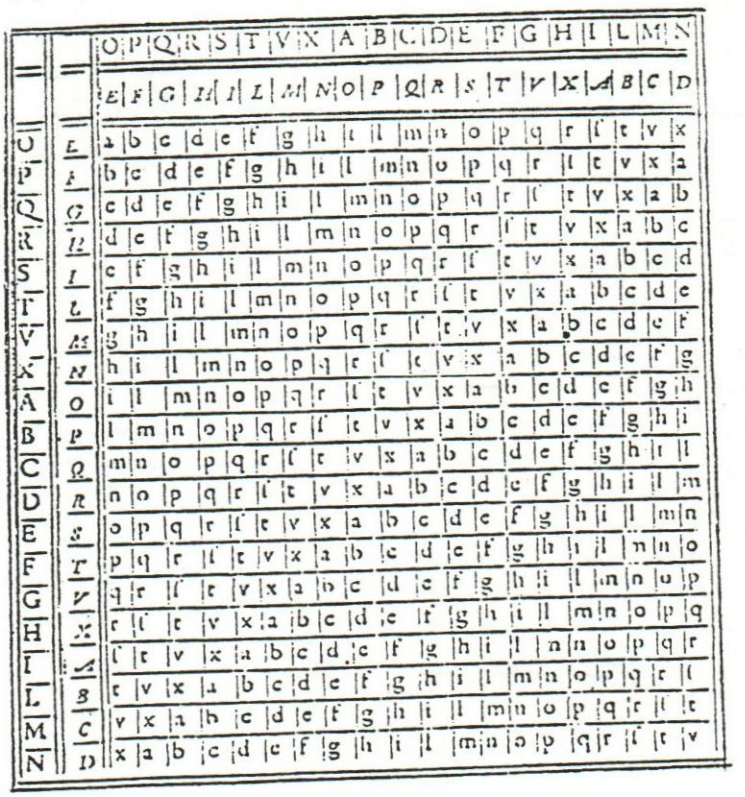


Figure 27.

"An Example of a Bi-literaire Alphabet," that is, one composed of two elements which, taken in groupings of fives, yields 32 permutations. You can use these permutations to represent the letters of the alphabet, says Bacon, but you need only 24 of them [because *I* and *J*, *U* and *V*, were then used interchangeably]. These permutations of two different things—they may be "*a*'s" and "*b*'s", "*1*'s" and "*2*'s", plusses and minuses, apples and oranges, anything you please—can be used to express or signify messages. Bacon was, in fact, the inventor of the binary code which forms the basis of modern electronic digital computers. Bacon gives a brief example in the word "FUGE"—the Latin equivalent for our modern "SCRAM"—as can be seen in Fig. 31. Figure 32 is another example, which quite obviously isn't what it appears to be—a crude picture of a castle, in which there are shaded and unshaded stones. It was drawn by a friend who was a physician and the message conveyed by it is:

My business is to write prescriptions
And then to see my doses taken;
But now I find I spend my time
Endeavoring to out-Bacon Bacon.

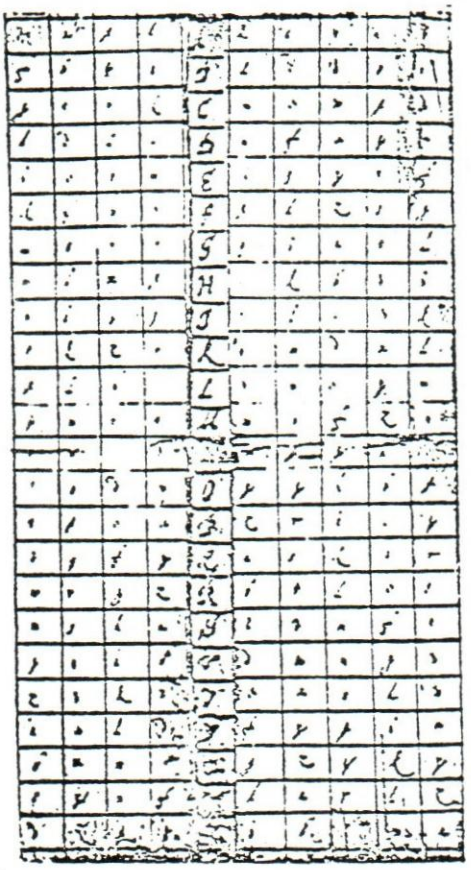


Figure 28.

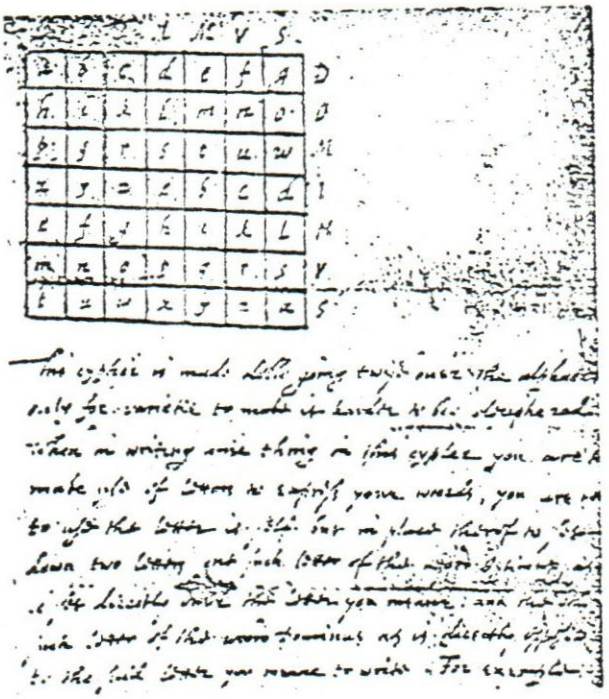


Figure 29.

So far all this is simple enough—too much so, Bacon says, for the example he used in the case of the word FUGE is patently cryptic and would not avoid suspicion under examination. So Bacon goes on to describe the next step, which is to have at hand a "Bi-formed Alphabet," that is, one in which all the letters of the alphabet, both capital and small, are represented by two slightly different forms of letters (Fig. 33). Having these two different forms at hand, when you want to encipher your secret message, you write another external and innocuous message five times as long as your secret message, using the appropriate two forms of letters to correspond to the "*a*'s" and "*b*'s" representing your secret message. Here's FUGE (Fig. 34), enciphered within an external message saying "Manere te volo donec veniam," meaning "Stay where you are until I come." In other words, whereas the real message says "SCRAM," the phoney one says "Stick around awhile; wait for me." Bacon gives a much longer example, the SPARTAN DISPATCH; here it is, and here's the secret message which it contains (Fig. 35).

Bacon's biliteral cipher is an extremely ingenious contrivance. There can be no question whatsoever about its authenticity and utility as a valid cipher. Thousands of people have checked his long example and they all find the same answer—the one that Bacon gives.

Figure 36 is a modern example which uses two slightly different fonts of type called Garamond and Imprint, and which are so nearly alike that it takes good eyes to differentiate them.

The fact that Bacon invented this cipher and described it in such detail lends plausibility to a theory entertained by many persons that Bacon wrote the Shakespeare Plays and that he inserted secret messages in those plays by using his cipher. If you'd like to learn more about this theory I suggest with some diffidence that you read a book entitled *The Shakespearean Ciphers Examined.* I use the word diffidence because my wife and I wrote the book which was published in late 1957 by the Cambridge University Press.

In the next lecture we'll take up cryptology as used during the period of the American Revolution by both the Colonial and the British Forces in America.

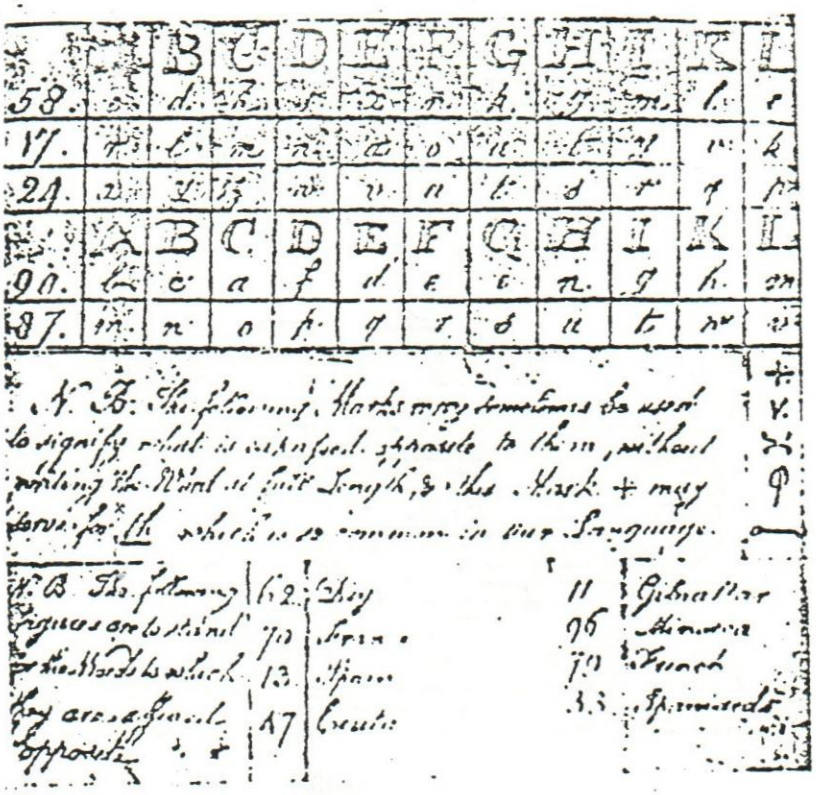


Figure 30.

An Example of a Bi-literarie Alphabet.

A	B	C	D	E	F
aaaaa	aaaab.	aaaba.	aaabb.	aabaa.	aabab.
G	H	I	K	L	M
aabba	aabbb	abaaa.	abaab.	ababa.	ababb.
N	O	P	Q	R	S
abbaa.	abbab.	abbba.	abbbb.	baaaa.	baaab.
T	V	W	X	Y	Z
baaba.	baabb.	babaa.	babab.	babba.	babbb.

Neither is it a ſmall matter theſe *Cypher-Characters* have, and may performe: For by this *Art* a way is opened, whereby a man may expreſſe and ſignifie the intentions of his minde, at any diſtance of place, by objects which may be preſented to the eye, and accommodated to the eare: provided thoſe objects be capable of a twofold difference onely, as by Bells, by Trumpets, by Lights and Torches, by the report of Muskets, and any inſtruments of like nature. But to purſue our enterpriſe, when you addreſſe your ſelfe to write, reſolve your inward-infolded Letter into this *Bi-literarie Alphabet*. Say the *interiour Letter* be

Fuge.

Example of Solution.

F.	V.	G.	E
Aabab.	baabb.	aabba.	aabaa.

Together

Figure 31.

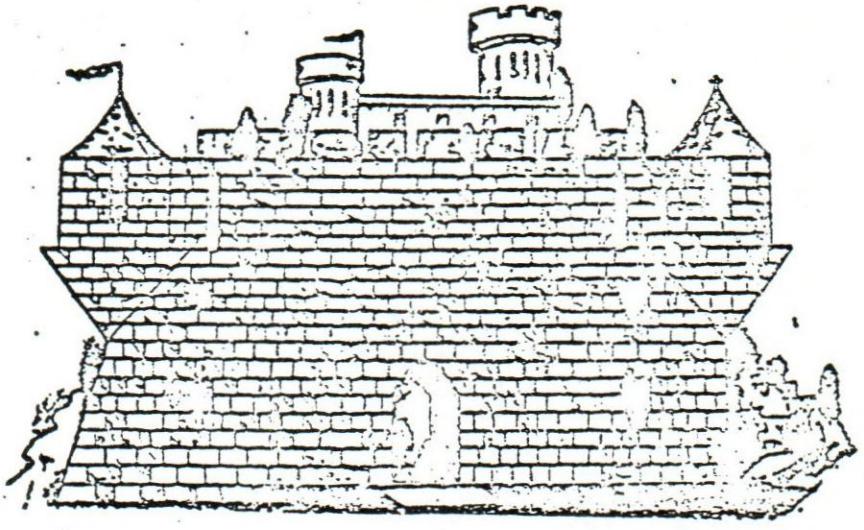


Figure 32.

Together with this, you must have ready at hand a *Bi-formed Alphabet*, which may represent all the *Letters* of the *Common Alphabet*, as well Capitall Letters as the Smaller Characters in a double forme, as may fit every mans occasion.

An Example of a Bi-formed Alphabet.

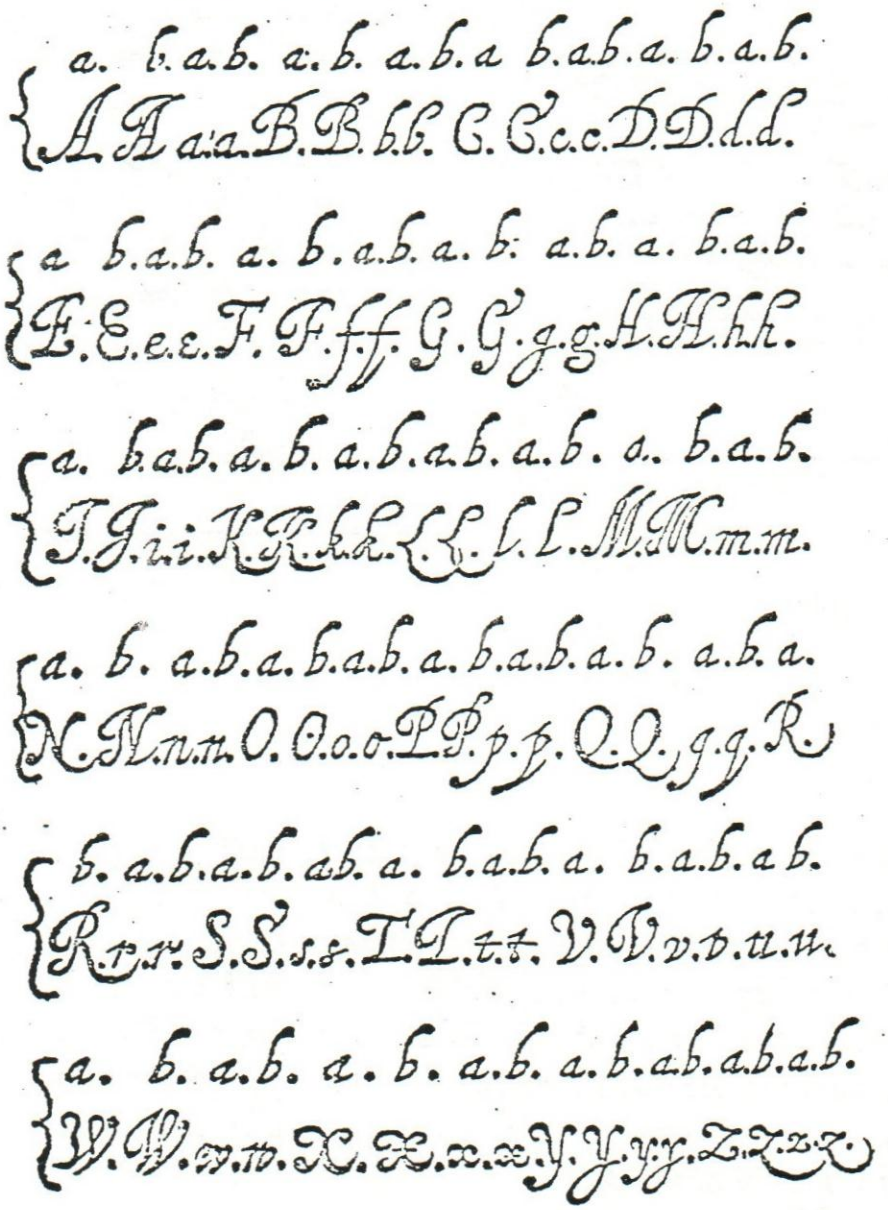
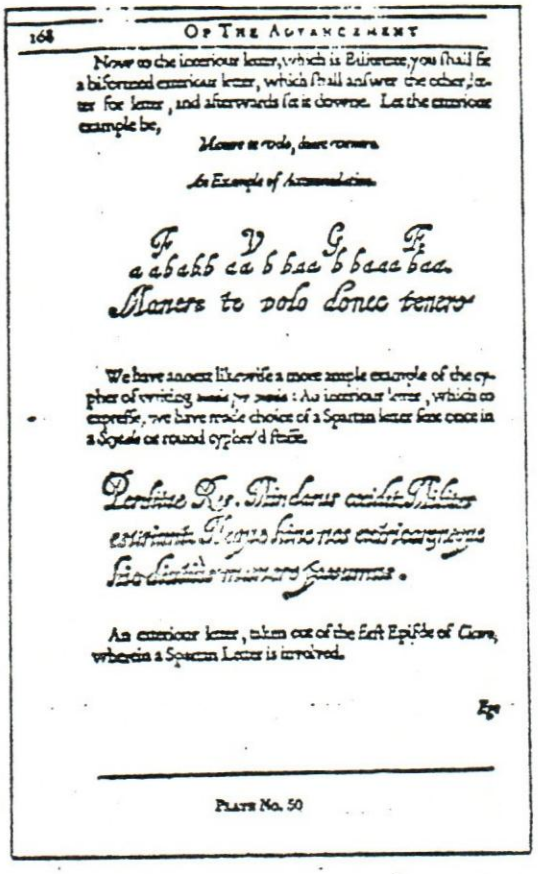


Figure 33.



168 OF THE ADVANCEMENT

Now to the inuersiue letter, which is Bilitteratiue, you shall set a bisformed enuersiue letter, which shall answer the other, letter for letter, and afterwards set it downe. Let the enuersiue example be,

Manere te volo, donec veniam.

An Example of Accommodation.

F a a b a b b a a G b a a a b a a F a a.

Manere te volo donec veniam.

We have annext likewise a more ample example of the cypher of writing [illegible]: An inuersiue letter, which to expresse, we have made choice of a Spartan letter sent once in a Scytale or round cypher'd staffe.

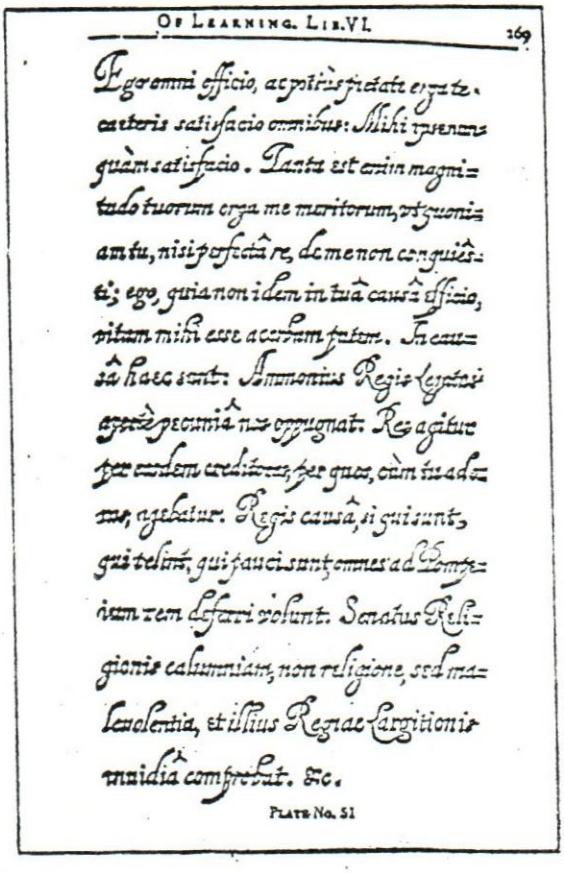
Perstitit Rex. Mandatum occultè filiis exhibuit. Regnum hinc meis exterminandum, hinc sibi tuendum mandavit. Successum.

An enuersiue letter, taken out of the first Epistle of Cicero, wherein a Spartan Letter is involved.

Ego

PLATE No. 50

Figure 34.



OF LEARNING. LIB. VI. 169

Ego omni officio, ac pietate erga te, cæteris satisfacio omnibus: Mihi ipsi non quàm satisfacio. Tanta est enim magnitudo tuorum erga me meritorum, ut quoniam amitu, nisi perficiâre, de me non conquiescâs; ego, quia non idem in tuâ causâ officio, vitam mihi esse acerbam fatear. In causâ hæc sunt: Ammonius Regis legatus aperte pecuniâ nos oppugnat. Res agitur per eosdem creditores, per quos, cùm tu aderas, agebatur. Regis causâ, si qui sunt, qui telum, qui faces sunt, omnes ad eamdem rem defendi volunt. Senatus Religionis calumniam, non religione, sed malevolentia, et illius Regiæ largitionis invidiâ comprobat. &c.

PLATE No. 51

Figure 35.

In all duty or rather piety towards you I satisfy every body except myself. Myself I never satisfy. For so great are the services which you have rendered me, that seeing you did not rest in your endeavours on my behalf till the thing was done, I feel as if life had lost all its sweetness, because I cannot do as much in this cause of yours. The occasions are these: Ammonius the King's ambassador openly besieges us with money: the business is carried on through the same creditors who were employed in it when you were here, &c.

Figure 36.

Lecture III

Continuing with our survey of cryptologic history, the period of the American Revolution, in U. S. history, is naturally of considerable interest to us and warrants more than cursory treatment. Information regarding the codes and ciphers employed during that period has been rather sparse until quite recently, when a book entitled *Turncoats, Traitors and Heroes* by Col. John Bakeless, AUS, was published in 1959 by Lippincott. After a good many years of research Col. Bakeless brought together for the first time a considerable amount of authentic information on the subject, and some of it is incorporated in this lecture.

According to Col. Bakeless—and believe it or not—in early 1775 the British commander-in-chief in America, General Gage, had no code or cipher at all, nor even a staff officer who knew how to compile or devise one; he had to appeal to the commanding general in Canada, from whom he probably obtained the single substitution cipher which was used in 1776 by a British secret agent who—again, believe it or not—was General Washington's own director-general of hospitals, Dr. Benjamin Church. General Washington had means for secret communication from the very beginning of hostilities, probably even before the fighting began at Lexington and Concord. If the British under General Gage were poorly provided in this respect, by the time Sir Henry Clinton took over from General Howe, who succeeded Gage, they were much better off—they had adequate or apparently adequate means for secret communication.

Are you astonished to learn that the systems used by the American colonial forces and by the British regulars were almost identical? You shouldn't be, because the language and backgrounds of both were identical. In one case, in fact, they used the same dictionary as a code book, something which was almost inevitable because there were so few English dictionaries available. Here's a list of the systems they used:

a. Simple, monoalphabetic substitution—easy to use and to change.

b. Monoalphabetic substitution with variants, by the use of a long key sentence. I'll show you presently an interesting example in Benjamin Franklin's system of correspondence with the elder Dumas.

c. The Vigenère cipher with repeating key.

d. Transposition ciphers of simple sorts.

e. Dictionaries employed as codebooks, with and without added encipherment. Two were specially favored, Entick's *New Spelling Dictionary*, and Bailey's *English Dictionary*. A couple of pages from the former are shown in Fig. 37. To represent a word by code equivalent you simply indicated the page number, then whether column 1 or column 2 contained the word you wanted, and then the number of the word in the column. Thus: The word "jacket" would be represented by 178–2–2.

f. Small, specially compiled, alphabetic one-part codes of 600–700 items and code names—our old friend the syllabary, or repertory, of hoary old age, but in new dress. In some cases these were of the "one-part" or "alphabetic" type.

g. Ordinary books, such as Blackstone's *Commentaires on the Laws of England*, giving the page number, the line number and the letter number in the line, to build up, letter-by-letter, the word to be represented. Thus: 125–12–16 would indicate the 17th letter in the 12th line on page 125; it might be the letter T.

h. Secret inks. Both the British and the Americans made extensive use of this method.

i. Special designs or geometric figures, such as one I'll show you presently.

j. Various concealment methods, such as using hollow quills of large feathers or hollowing out a bullet and inserting messages written on very thin paper. Strictly speaking, however, this sort of strategem doesn't belong to the field of cryptology. But it's a good dodge, to be used in special cases.

178 JAC JAU

Hyp, *v. a.* to make melancholy, to dispirit
Hypallage, *s.* a change of cases, *&c.*
Hyperbole, *s.* an exaggeration, a diminution
Hyperbolical, *a.* exaggerating or extenuating
Hyperborean, *a.* northern
Hyper, Hypercritic, *s.* a critic exact beyond reason
Hypercritical, *a.* critical beyond use, severe
Hypermeter, *s.* what is above the standard
Hypersarcosis, *s.* a growth of proud flesh
Hyphen, *s.* (-) between words or syllables
Hypnotic, *s.* a medicine causing sleep
Hypochondriac, *s.* one affected with melancholy
Hypochondriacal, *a.* melancholy
Hypocrisy, *s.* dissimulation, a pretence
Hypocrite, *s.* a dissembler in religion, *&c.*
Hypocritical, *a.* dissembling, insincere, false
Hypocritically, *ad.* without sincerity, falsely
Hypogastric, *a.* in the lower part of the belly
Hypostasis, *s.* a distinct substance, personality
Hypostatical, *a.* constitutive, distinct, personal
Hypothesis, *s.* a system upon supposition
Hypothetical, *a.* supposed, conditional
Hypothetically, *ad.* upon supposition
Hyrst, Hurst or Herst, *s.* a wood
Hyssop, *s.* a plant
Hysteric, *a.* troubled with fits
Hysterics, *s. pl.* fits of women

I.

I *pron.* myself
Jabber, *v. n.* to talk idly, to chatter
Jabberer, *s.* one who talks unintelligibly
Jacent, *a.* lying at length, extended
Jacinth, *s.* a gem, the hyacinth
Jack, *s.* John, an engine, fish, leathern-cann
Jackal, *s.* a beast that starts the lion's prey
Jackalent, *s.* a simple sheepish fellow
Jackanapes, *s.* a monkey, a coxcomb
Jackboots, *s.* boots serving for armor
Jackdaw, *s.* a chattering bird
Jacket, *s.* a waistcoat, a short coat
Jackpudding, *s.* a merry andrew, a buffoon
Jacobite, *s.* a partizan of James II.
Jactitation, *s.* a tossing motion, restlessness
Jaculation, *s.* the act of throwing or darting
Jade, *s.* a bad woman, a worthless horse
Jade, *v. a.* to tire, weary, ride down, flog
Jadish, *a.* unruly, vicious, unchaste
Jag, *v. a.* to notch; *s.* a denticulation, uneveness
Jagging, *s.* a cutting in notches
Jaggy, *a.* uneven, notched
Jail, *s.* a prison, a goal
Jailer, *s.* the keeper of a prison
Jakes, *s.* a house of ease, a bogghouse
Jam, *s.* a confetture of fruit, a child's frock
Jam, *v. a.* to confine between, to wedge in
Jamb, *s.* the upright post of a door
Jambic, *s.* verses composed of a long and a short syllable alternately
Jangle, *v. n.* to wrangle, to be out of tune
Janizary, *s.* a Turkish soldier, a guard
Jantty, *a.* showy, fluttering, gay, giddy
January, *s.* the first month of the year
Japan, *s.* a varnish to work in colors
Japan, *v. a.* to varnish, to black shoes
Japanner, *s.* a shoeblack, one who japans
Jar, *v. n.* to clash, disagree, differ, quarrel
Jar, *s.* discord, a harsh sound, an earthen vessel
Jargogle, *v. a.* to confound, perplex, pervert
Jargon, *s.* gibberish, gabble, nonsense
Jasmine, Jessamine, *s.* a flower
Jasper, *s.* a precious green stone
Javelin, *s.* a spear or half pike
Jaundice, *s.* a distemper
Jaundiced, *a.* affected with the jaundice
Jaunt, *v. n.* to walk or travel about
Jaunt, *s.* a ramble, excursion, folly

Jauntily,

Figure 37.

In the way of ciphers a bit more complex than simple monoalphabetic substitution ciphers, the British under Clinton's command used a system described by Bakeless in the following terms:

> "... a substitution cipher in which the alphabet was reversed, 'z' becoming 'a' and 'a' becoming 'z'. To destroy frequency clues, the cipher changed in each line of the message, using 'y' for 'a' in the second line, 'x' for 'a' in the third, and so on. When the cipher clerk reached 'o' in the middle of the alphabet, he started over again. A spy using this cipher did not have to carry incriminating papers, since the system was so easy to remember."

The alphabets of this scheme are simple reversed standard alphabets:

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

Bakeless doesn't explain why the cipher sequences are only 12 in number— nor does the source from which he obtained the information, a note found among the *Clinton Papers* in the Clements Library at the University of Michigan.

Bakeless continues:

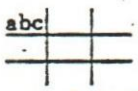
> "Clinton also used another substitution cipher, with different alphabets for the first, second and third paragraphs. Even if an American cryptanalyst should break the cipher in one paragraph, he would have to start all over in the next. As late as 1781, however, Sir Henry was using one extremely easy substitution cipher, in which 'a' was 51, 'd' was 54, 'e', 55. Finding that 'a' was 51 and 'd' was 54, anyone could guess (correctly) that 'b' was 52, 'c' 53. Somewhat more complex was his 'pigpen' cipher, in which twenty-five letters of the alphabet were placed in squares. Then an angle alone would represent a letter, the same angle with a dot another letter, the same angle with two dots still another. In some cases, cryptography was used only for a few crucial words in an otherwise 'clear' message, a method also favored by certain American officials."

Of the first cipher mentioned in the preceding extract, there is much more to be said. Perhaps Bakeless was limited by space considerations. In any case, I will leave that story for another time and place. As for the second cipher Bakeless mentions in the extract, I can give you the whole alphabet, for it exists among the *Clinton Papers*.

A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	Q	R	S	T	U	W	X	Y	Z
51	52	53	54	55	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78

There is no explanation why the sequence beginning with 50 stops with E–55 and then, starting with F–60 goes straight on without any break to Z–78. (Remember that in those days I and J were used interchangeably, as were U and V.)

Finally, as to what Bakeless (and others) call the "pigpen" cipher, this is nothing but the hoary old so-called "Masonic" cipher based upon the 4-cross figure



a– ⌋ b– .⌋ c– ..⌋

which can accommodate 27 characters, not 25, as Bakeless indicates. Letters can be inserted in the design in many different arrangements.

I've mentioned that code or conventional names were used to represent the names of important persons and places in these American colonial and British cryptograms of the Revolution. Here are examples selected from a list of code names prepared by the famous British spy, Major André, chief of intelligence under General Clinton:

For American Generals—the names of the Apostles, for instance:

General Washington was *James*
General Sullivan was *Matthew*

Names of Forts:

Fort Wyoming—*Sodom*
Fort Pitt—*Gomorrha*

Names of Cities:

Philadelphia—*Jerusalem*
Detroit—*Alexandria*

Names of Rivers and Bays:

Susquehanna—*Jordan*
Delaware—*Red Sea*

Miscellaneous:

Indians—*Pharisees*
Congress—*Synagogue*

I'm sure you've learned as school children all about the treasonable conduct of Benedict Arnold when he was in command of the American Forces at West Point; but you probably don't know that practically all his exchanges of communications with Sir Henry Clinton, Commander of the British Forces in America, were in cipher or in invisible inks. One of Arnold's cipher messages, in which he offers to give up West Point for £20,000 is shown below, Fig. 38*a* being the secret version, Fig. 38*b*, the plain text. Arnold left a few words *en clair*, the ones

Figure 38*a*.

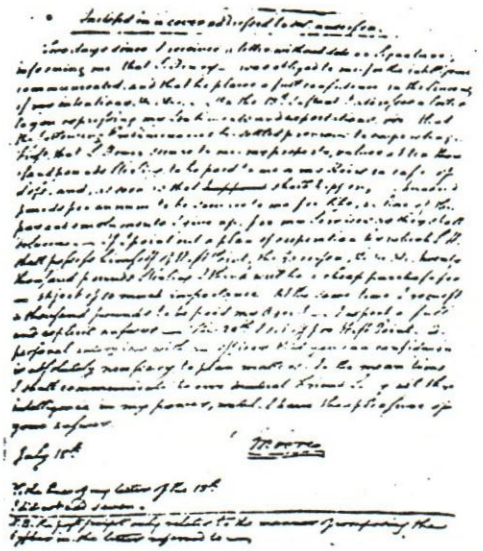
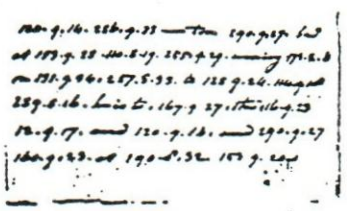


Figure 38*b*.

he considered unimportant; for the important ones he used a dictionary as a codebook, indicating the page number, column number and line number corresponding to the position in the dictionary of the plaintext word which the code group represents. Arnold added 7 to these numbers, which accounts for the fact that the first number in a code group is never less than 8, the central number is always either 8 or 9, and the third number is never less than 8 or more than 36. The significant sentence appears near the middle of the message: "If I 198–9–34, 185–8–31 a 197–8–8 . . . " yields the plain text: "If I point out a plan of cooperation by which S. H. (Sir Henry Clinton) shall possess himself of West Point, the Garrison, etc., etc., etc., twenty thousands pound Sterling I think will be a cheap purchase for an object of so much importance." The signature 172–9–19 probably stands for the word "Moor"; Arnold's code name in these communications was "John Moore." He had also another name, "Gustavus."



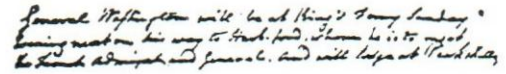
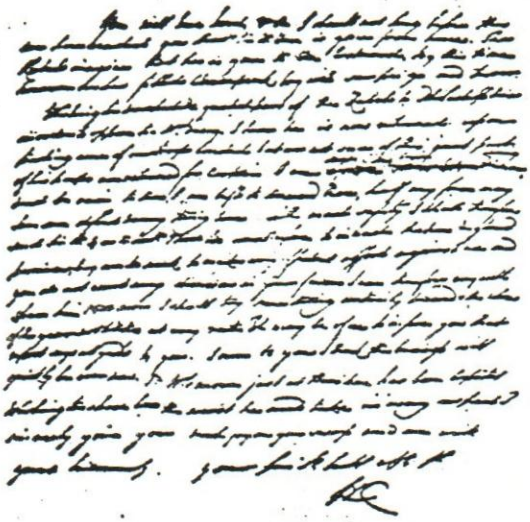
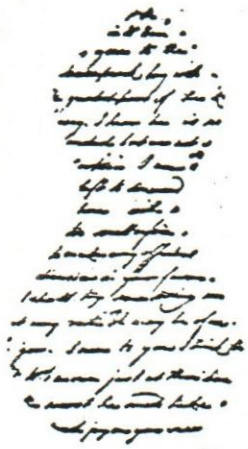


Figure 39.

Figure 39 is a message in which he gave the British information which might have led to the capture of his commander-in-chief, General Washington; the top shows the code message, the bottom the plain text. Arnold used the same additive as in the preceding example. Washington, however, was too smart to be ambushed—he went by a route other than the one he said he'd take.





Sir
W. Howe
is gone to the
Cheasapeak bay with
the greatest part of the
army. I hear he is now
landed but am not
certain. I am
left to command
here with a
too small force
to make any effectual
diversion in your favor
I shall try something cer
At any rate It may be of use
to you. I own to you I think
Sr W's move just at this time
the worst he could take
much joy on your success

Figure 40.

You may find Fig. 40 interesting as an example of the special sort of mask or grille used by Arnold and by the British in their negotiations with him. The real or significant text is written in lines outlined by an hourglass figure and then dummy words are supplied to fill up the lines so that the entire letter apparently makes good sense. To read the secret message, you're supposed to have the same size hourglass figure that was used to conceal the secret message. In Fig. 40 the left-hand portion shows the "phoney" message. Masks having small rectangular apertures were also used, the significant words being written so that they were disclosed when the mask was placed on the written message so as to isolate them from the non significant words. The significant text in this example is shown in printed form to the right of the original hourglass design.

An interesting episode involving concealment of this sort is recorded by Bakeless. An urgent message from Sir Henry Clinton, dated 8 October 1777, and written on thin silk, was concealed in an oval silver ball, about the size of a rifle bullet, which was handed to Daniel Taylor, a young officer who had been promised promotion if he got through alive. The bullet was made of silver, so that the spy could swallow it without injury from corrosion . . . Almost as soon as he started, Taylor was captured . . . Realizing his peril too late, the spy fell into a paroxysm of terror and, crying, "I am lost," swallowed the silver bullet. Administration of a strong emetic soon produced the bullet with fatal results, for Taylor was executed. "A rather heartless American joke went around," adds Bakeless, "that Taylor had been condemned 'out of his own mouth'."

We next see (Fig. 41) one Benedict Arnold message that never was deciphered. It is often referred to as "Benedict Arnold's Treasonable Cow Letter." Only one example is extant; certain words have purely arbitrary meanings, as prearranged. The letter was written just two weeks before the capture of Major André.

In Fig. 42, we see a British cipher message of the vintage 1781. It was deciphered *before* finding the key, always a neat trick when or if you can do it. The key—the title page of the then current British Army List—is shown in Fig. 43. The numbers in the cipher text obvi-

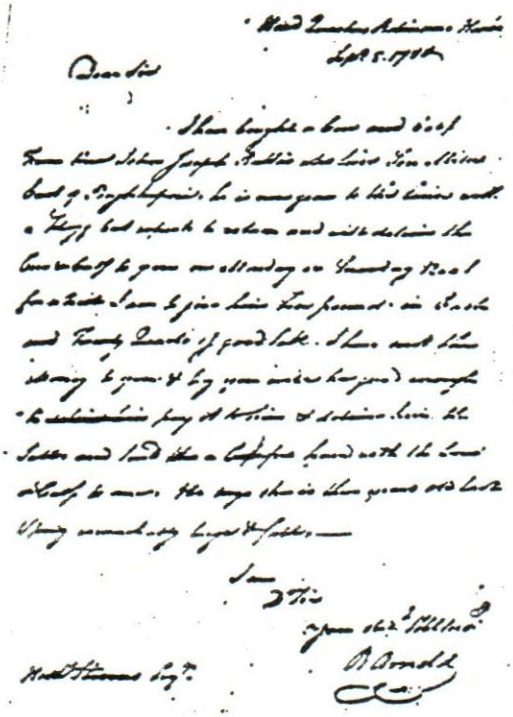


Figure 41.

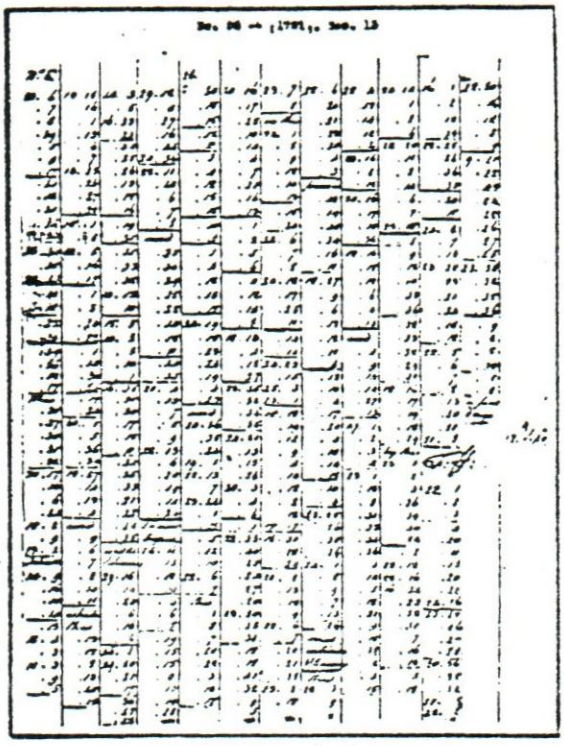
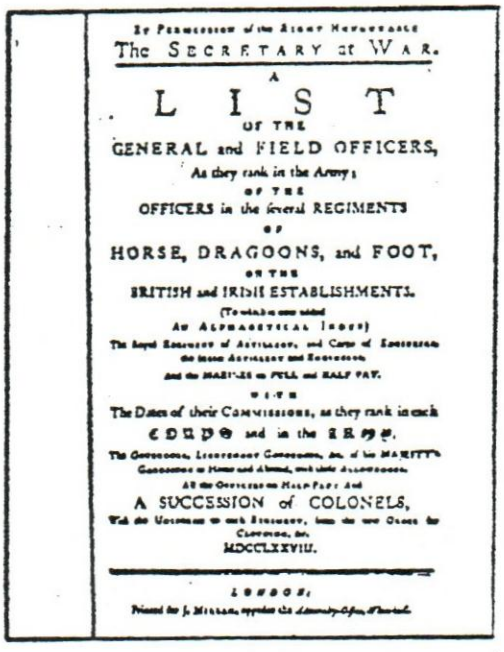


Figure 42.

'sly refer to line numbers and letter numbers in the line of a key text, the first series of num-
ers, viz., 22.6.7.39.5.9.17, indicating line number 22, letter numbers 6.7.39.5.9.17 in that line.
Because of so many repetitions, the plain text was obtained by straightforward analysis by an
officer recently on (to whom I am indebted



By Permission of the Right Honourable
The SECRETARY at WAR.

A

LIST

OF THE

GENERAL and FIELD OFFICERS,

As they rank in the Army;

OF THE

OFFICERS in the several REGIMENTS

OF

HORSE, DRAGOONS, and FOOT,

ON THE

BRITISH and IRISH ESTABLISHMENTS.

(To which are added

An Alphabetical Index)

The Royal Regiment of Artillery, and Corps of Engineers,

the Horse Artillery and Engineers,

and the MARINES on FULL and HALF PAY.

WITH

The Dates of their Commissions, as they rank in each

GRADE and in the REGIMENT.

The Governors, Lieutenant Governors, &c. of the MARITIME

Garrisons at Home and Abroad, and their Allowances.

All the Officers on Half Pay, and

A SUCCESSION of COLONELS,

With the Vacancies in each Regiment, from the two Oldest for

Chatham, &c.

MDCCLXXVIII.

LONDON:

Figure 43.

for this interesting example. The plain text, once obtained, gave him clues as to what the key text might be, simply by placing the plaintext letters in their numerical-equivalent order in the putative key text. This done, was quick to realize what the key text was—a British Army List. The date of the message enabled him to find the list without much difficulty in the Library of Congress (Fig. 43).

There was an American who seems to have been the Revolution's one-man National Security Agency, for he was the one and only cryptologic expert Congress had, and, it is claimed, he managed to decipher nearly all, if not all, of the British code messages obtained in one way or another by the Americans. Of course, the chief way in which enemy messages could be obtained in those days was to capture couriers, knock them out or knock them off, and take the messages from them. This was very rough stuff, compared to getting the material by radio intercept, as we do nowadays.

I think you'll be interested to hear a bit more about that one-man NSA. His name was James Lovell and besides being a self-trained cryptologist, he was also a member of the Continental Congress. There's on record a very interesting letter which he wrote to General Nathaniel Greene, with a copy to General Washington. Here it is.

Philadelphia, Sept. 21, 1781

Sir:

You once sent some papers to Congress which no one about you could decypher. Should such be the Case with some you have lately forwarded I presume that the Result of my pains, here sent, will be useful to you. I took the Papers out of Congress, and I do not think it necessary to let it be known here what my success has been in the attempt. For it appears to me that the Enemy make only such Changes in their Cypher, when they meet with misfortune, as makes a difference of Position only to the same Alphabet, and therefore if no talk of Discovery is made by us here or by your Family, you may be in Chance to draw Benefit this Campaign from my last Night's Watching.

I am Sir with much respect,

Your Friend,
JAMES LOVELL

Maj. Genl. Greene
(With copy to Genl. Washington)

In telling you about Lovell I should add to my account of that interesting era in cryptologic history an episode I learned about only recently. When a certain message of one of the generals in command of a rather large force of Colonials came into Clinton's possession he sent it off posthaste to London for solution. Of course, Clinton knew it was going to take a lot of time for the message to get to London, be solved and returned to America—and he was naturally a bit impatient. He felt he couldn't afford to wait that long. Now it happened that in his command there were a couple of officers who fancied themselves to be cryptologists and they undertook to solve the message, a copy of which had been made before sending the original off to London. Well, they gave Sir Henry their solution and he acted upon it. The operation turned out to be a dismal failure, because the solution of the would-be cryptanalysts happened to be quite wrong! The record doesn't say what Clinton did to those two unfortunate cryptologists when the correct solution arrived from London some weeks later. By the way, you may be interested in learning that the British operated a regularly established cryptanalytic bureau as early as in the year 1630 and it continued to operate until the end of July 1844. Then there was no such establishment until World War I. I wish there were time to tell you some of the details of that fascinating and little known bit of British history.

There's also an episode I learned about only very recently, which is so amusing I ought to share it with you. It seems that a certain British secret agent in America was sent a message in plain English, giving him instructions from his superior. But the poor fellow was illiterate and there wasn't anything to do but call upon the good offices of a friend to read it to him. He found such a friend, who read him his instructions. What he didn't know, however, was that the friend who'd helped him was one of General Washington's secret agents!

The next illustration (Fig. 44) is a picture of one of several syllabaries used by Thomas Jefferson. It is constructed on the so-called two-part principle, which was explained in the preceding lecture. Figure 44*a* is a portion of the encoding section, and Fig. 44*b* is a portion of the decoding section, in which the code equivalents are in numerical order accompanied by their meanings as assigned them in the encoding section. This sort of system, which, as I've already explained, was quite popular in Colonial times as in the early days of Italian cryptography, is still in extensive use in some parts of the world.

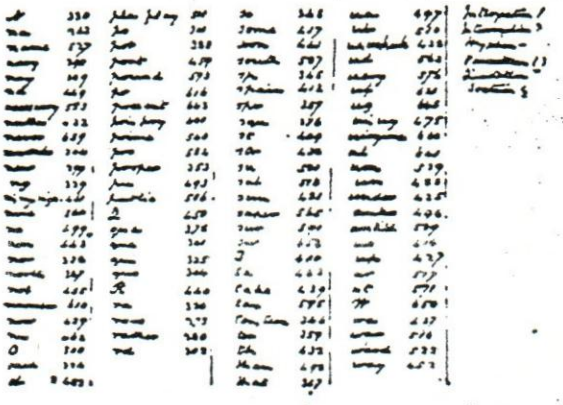


Figure 44*a*.

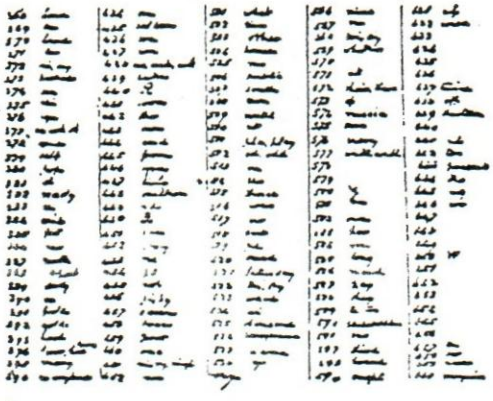


Figure 44*b*.

A few minutes ago I mentioned Benjamin Franklin's cipher system, which, if used today, would be difficult to solve, especially if there were only a small amount of traffic in it. Let me show you what it was. Franklin took a rather lengthy passage from some book in French and numbered the letters successively. These numbers then became equivalents for the same letters in a message to be sent. Because the key passage was in good French, naturally there were many variants for the letter E—in fact, there were as many as one would expect in normal plaintext French; the same applied to the other high-frequency letters such as R, N, S, I, etc. What this means, of course, is that the high-frequency letters in the plain text of any message to be enciphered could be represented by many different numbers and a solution on the basis of frequency and repetitions would be very much hanpered by the presence of many variant values for the same plaintext letter. In Fig. 45 you can see this very clearly.

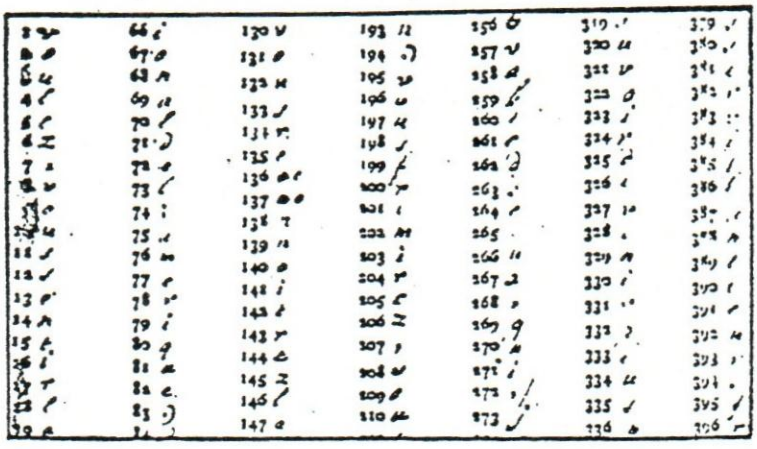


Figure 45.

I know of but one case in all our U. S. history in which a resolution of Congress was put out in cryptographic form. It is shown in Fig. 46—a resolution of the Revolutionary Congress dated 8 February 1782. I have in my collection not only a copy of the resolution but also a copy of the syllabary by which it can be deciphered.

Interest in cryptology in America seems to have died with the passing of Jefferson and Franklin. But if interest in cryptology in America wasn't very great, if it existed at all after the Revolution, this was not the case in Europe. Books on the subject were written, not by professionals, perhaps, but by learned amateurs, and I think you will find some of them in the NSA library if you're interested in the history of the science. The next illustration (Fig. 47) is the frontispiece of a French book the title of which (translated) is "Counter-espionage, or keys for all secret communications." It was published in Paris in 1793. In the picture, we see Dr. Cryppy himself, and perhaps a breadboard model of a GS-11 research analyst, or maybe an early model of a WAC.

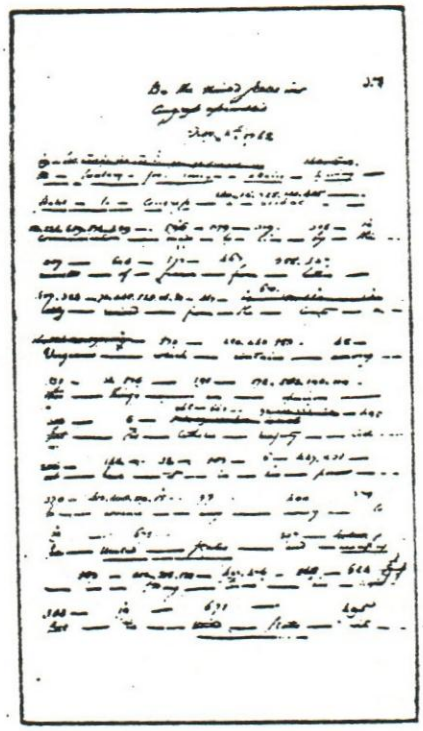


Figure 46.

I am now going to tell you something about the early steps in finding an answer to the age-old mystery presented by Egyptian hieroglyphics, not only because I think that the solution represents the next landmark in the history of cryptology, but also because the story is of general interest to any aspiring cryptologist. About 1821 a Frenchman, Champollion, startled the world by beginning to publish translations of Egyptian hieroglyphics, although in the budding new field of Egyptology much had already transpired and been published. In Fig. 48 we see the gentleman and in Fig. 49, a picture of the great Napoleonic find that certainly facilitated and perhaps made possible the solution of the Egyptian hieroglyphic writing—the Rosetta Stone. The Rosetta Stone was found in 1799 at Rashid, or, as the Europeans call it, Rosetta, a town in northern Egypt on the west bank of the Rosetta branch of the Nile. Rosetta was in the vicinity of Napoleon's operations which ended in disaster. When the peace treaty was written, Article 16 of it required that the Rosetta Stone, the significance of which

quickly understood by both the conquered French and victorious British commanders, be shipped to London, together with certain other large antiquities. The Rosetta Stone still occupies a prominent place in the important exhibits at the British Museum. The Rosetta Stone is a bilingual inscription, because it is in Egyptian and also Greek. The Egyptian portion consists of two parts, the upper one in hieroglyphic form, the lower one in a sort of cursive

Figure 47.

Figure 48.

script, also Egyptian, but called "Demotic." It was soon realized that all three texts were supposed to say the same thing, of course, and since the Greek could easily be read, it served as something called in cryptanalysis a "crib." Any time you are lucky enough to find a crib it saves you hours of work. It was by means of this bilingual inscription that the Egyptian hieroglyphic writing was finally solved, a feat which represented the successful solution to a problem the major part of which was linguistic in character. The cryptanalytic part of the task was relatively simple. Nevertheless, I think that anyone who aspires to become a professional cryptologist should have some idea as to what that cryptanalytic feat was, a feat which some professor (but not of cryptologic science; I think it was Professor Norbert Wiener, of the Massachusetts Institute of Technology) said was the greatest cryptanalytic feat in history. We shall see how wrong the good professor was, because I'm going to demonstrate just what the feat really amounted to by showing you some simple pictures.

First, let me remind you that the Greek text served as an excellent crib for the solution of both Egyptian texts, the hieroglyphic and the Demotic, the latter merely being the conventional abbreviated and modified form of the Hieratic character or cursive form of hieroglyphic writing that was in use in the Ptolemaic Period.

The initial step was taken by a Reverend Stephen Weston who made a translation of the Greek inscription, which he read in a paper delivered before the London Society of Anitquaries, in April 1802.

In 1818 Dr. Thomas Young, the physicist who first proposed the wave theory of light, compiled for the 4th volume of *Encyclopaedia Britannica*, published in 1819, the results of his studies on the Rosetta Stone and among them there was a list of several Egyptian characters which, in most cases, he had assigned correct phonetic values. *He was the first to grasp the idea of a phonetic principle in the Egyptian hieroglyphs and he was the first to apply it to their decipherment.* He also proved something which others had only suspected, namely, that the

hieroglyphs in ovals or cartouches were royal names. But Young's name is not associated in the public mind with the decipherment of Egyptian hieroglyphics—that of Champollion is very much so. Yet much of what Champollion did was based upon Young's work. Perhaps the greatest credit should go to Champollion for recognizing the major importance of an ancient language known as Coptic as a bridge that could lead to the decipherment of the Egyptian hieroglyphics. As a lad of seven he'd made up his mind that he'd solve the hieroglyphic writing, and in the early years of the 19th Century he began to study Coptic. In his studies of the Rosetta Stone his knowledge of Coptic, a language the knowledge of which had never been lost, enabled him to deduce the phonetic value of many syllabic signs and to assign correct readings to many pictorial characters, the meanings of which became known to him from the Greek text on the Stone.

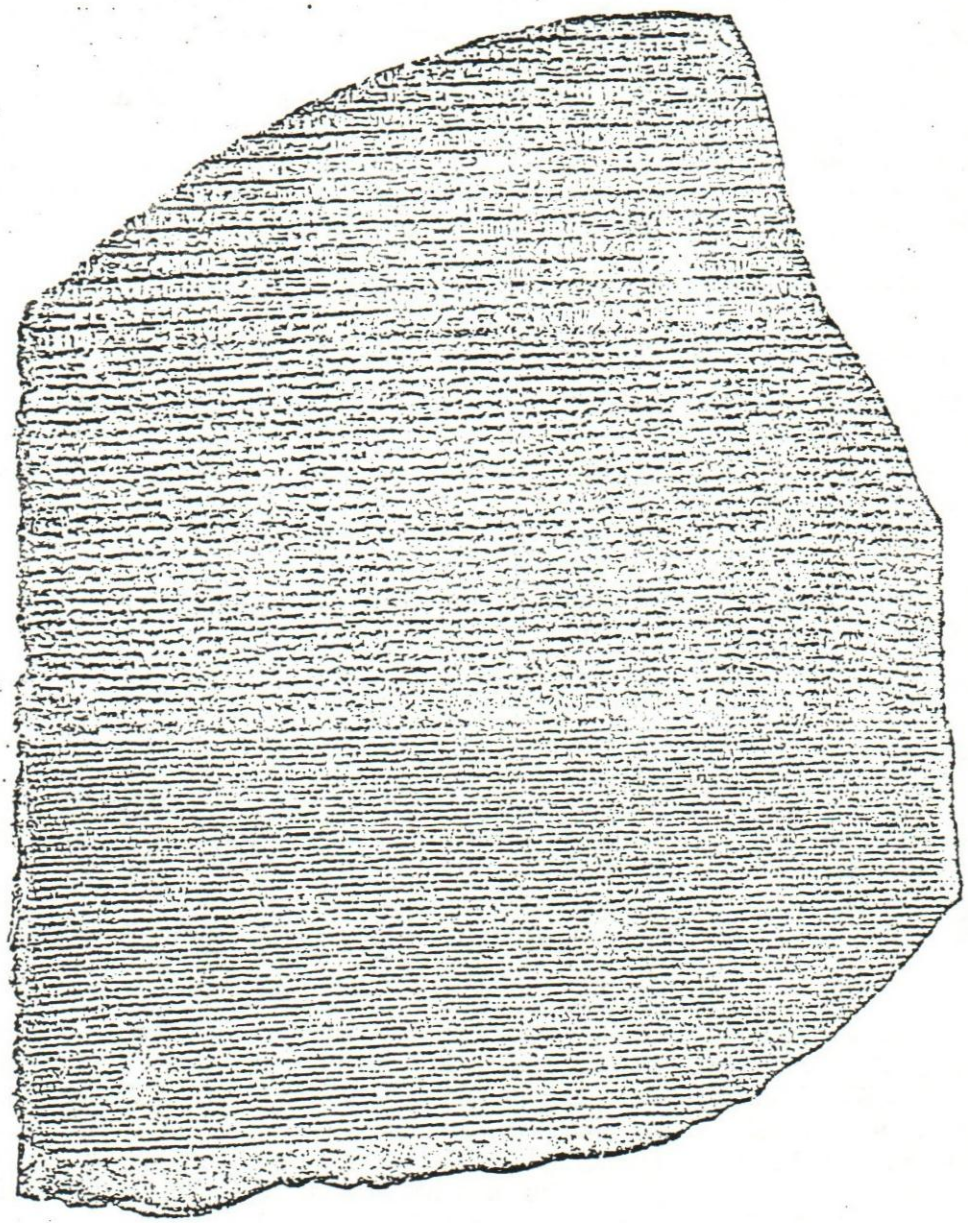
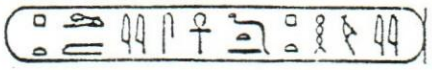
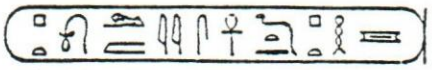


Figure 49.

The following step-by-step account of the solution is taken from a little brochure entitled *The Rosetta Stone*, published by the Trustees of the British Museum. It was written in 1922 E. A. Wallis Budge and was revised in 1950. I quote:

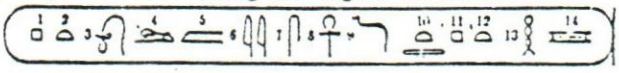
"The method by which the greater part of the Egyptian alphabet was recovered is this: It was assumed correctly that oval  , or "cartouche" as it is called, always contained a royal name. There is only one cartouche (repeated six times with slight modifications) on the Rosetta Stone, and this was assumed to contain the name of Ptolemy, because it was certain from the Greek text that the inscription concerned a Ptolemy. It was also assumed that if the cartouche did contain the name of Ptolemy the characters in it would have the sounds of the Greek letters, and that all together they would represent the Greek form of the name of Ptolemy. Now on the obelisk which a certain Mr. Banks had brought from Philae there was also an inscription in two languages, Egyptian and Greek. In the Greek portion of it two royal names are mentioned, that is to say, Ptolemy and Cleopatra, and on the second face of the obelisk there are two cartouches, which occur close together, and are filled with hieroglyphs which, it was assumed, formed the Egyptian equivalents of these names. When these cartouches were compared with the cartouche on the Rosetta Stone it was found that one of them contained hieroglyphic characters that were almost identical with those which filled the cartouche on the Rosetta Stone. Thus there was good reason to believe that the cartouche on the Rosetta Stone contained the name of Ptolemy written in hieroglyphic characters. The forms of the cartouches are as follows:

On the Rosetta Stone:— 

On the Obelisk from Philae:— 

In the second of these cartouches a single sign takes the place of three signs at the end of the first cartouche. Now it has already been said that the name of Cleopatra was found in Greek on the Philae Obelisk, and the cartouche which was assumed to contain the Egyptian equivalent to this name appears in this form:

Taking the cartouches which were supposed to contain the names of Ptolemy and Cleopatra from the Philae Obelisk, and numbering the signs we have:

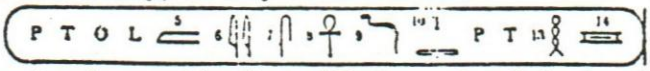
Ptolemy, A. 

Cleopatra, B. 

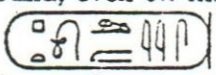
Now we see at a glance that No. 1 in A and No. 5 in B are identical, and judging only by their position in the names they must represent the letter P. No. 4 in A and No. 2 in B are identical, and arguing as before from their position, they must represent the letter L. As L is the second letter in the name of Cleopatra, sign No. 1 in B must represent K. In the cartouche of Cleopatra, we now know the values of Signs Nos. 1, 2 and 5; so we may write them down thus:

In the Greek form of the name of Cleopatra there are two vowels between the L and P, and in the hieroglyphic form there are two hieroglyphs, this  and this  , so we may assume that the first is E and the other O. In some forms of the cartouche of Cleopatra, No. 7 (the hand) is replaced by a half circle, which is identical with No. 2 in A and No. 10 in B. As T follows P in the name Ptolemy, and as there is a T in the Greek form of the name of Cleopatra, we may assume that the half circle and the hand have substantially the same sound, and that that sound is T. In the Greek form of the name Cleopatra there are two A's, the position of which agree with No. 6 and No. 9, and we may assume that the bird has the value of A. Substituting these values for the hieroglyphs in B we may write it thus:

Thomas Young noticed that the two signs 𓏏 and 𓂋 always followed the name of a goddess, or queen, or princess. Other early decipherers regarded the two signs as a mere feminine termination. The only sign for which we have no phonetic equivalent is No. 8, the lens, and it is obvious that this must represent R. Inserting this value in the cartouche we have the name Cleopatra deciphered. Applying now the values which we have learned from the cartouche of Cleopatra to the cartouche of Ptolemy, we may write it thus:

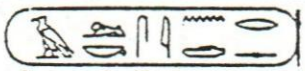


We now see that the cartouche must be that of Ptolemy, but it is also clear that there must be contained in it many other hieroglyphs which do not form part of his name. Other forms of the cartouche of Ptolemy are found, even on the stone, the simplest of them written thus:



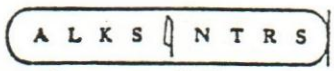
It was therefore evident that these other signs 𓇋𓏏𓂝𓏏 were royal titles corresponding to those found in the Greek text on the Rosetta Stone meaning "ever-living, beloved of Ptah." Now the Greek form of the name Ptolemy, i.e. Ptolemaios, ends with S. We may assume therefore that the last sign 𓊃 in the simplest form of the cartouche given above has the phonetic value of S. The only hieroglyphs now doubtful are 𓄿 and 𓇋 𓇋, and their position in the name of Ptolemy suggests that their phonetic values must be M and some vowel sound in which the I sound predominates. These values, which were arrived at by guessing and deduction, were applied by the early decipherers to other cartouches, e.g.:

1 

2 

Now in No. 1, we can at once write down the values of all the signs, viz., P. I. L. A. T. R. A., which is obviously the Greek name Philotera. In No. 2 we know only some of the hieroglyphs, and we write the cartouche thus:

It was known that the running-water sign 𓈖 occurs in the name Berenice, and that it represents N, and that this sign 𓋴 is the last word of the transcript of the Greek title "Kaisaros," and therefore represent some S sound. Some of the forms of the cartouche of Cleopatra begin with (𓎡), and it is clear that its phonetic value must be K. Inserting these values in the cartouche above we have:



which is clearly meant to represent the name "Alexandros," or Alexander. The position of this sign (𓇋) shows that it represented some sound of E or A.

Well, I've showed you enough to make fairly clear what the problem was and how it was solved. As you may already have gathered, the cryptanalysis was of a very simple variety.

The grammar?—Well, that's an entirely different story: There's where the difficult part lay. It was very fortunate that the first attacks on Egyptian hieroglyphics didn't have to deal with enciphered writing. Yes, the Egyptians also used cryptography; yes, there *are* "cryptographic hieroglyphics!" We'll get to these later, but at this point it may be of interest to many of you to learn something about what the Rosetta Stone had to say, as set forth by Dr. Budge:

> "The opening lines are filled with a list of the titles of Ptolemy V, and a series of epithets which proclaim the king's piety towards the gods, and his love for the Egyptians and his country. In the second section of the inscription the priests enumerate the benefits which he had conferred upon Egypt, and which may be thus summarized:
>
> 1. Gifts of money and corn to the temples.
> 2. Gifts of endowments to temples.

3. Remission of taxes due to the Crown.
4. Forgiveness of debts owed by the people to the Crown.

---

7. Reduction of fees payable by candidates for the priesthood.
8. Reduction of the dues payable by the temples to the Crown.

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13. Forgiveness of the debts owed by the priests to the Crown.
14. Reduction of the tax on byssus (a kind of flax or cotton fibre).
15. Reduction of the tax on corn lands.

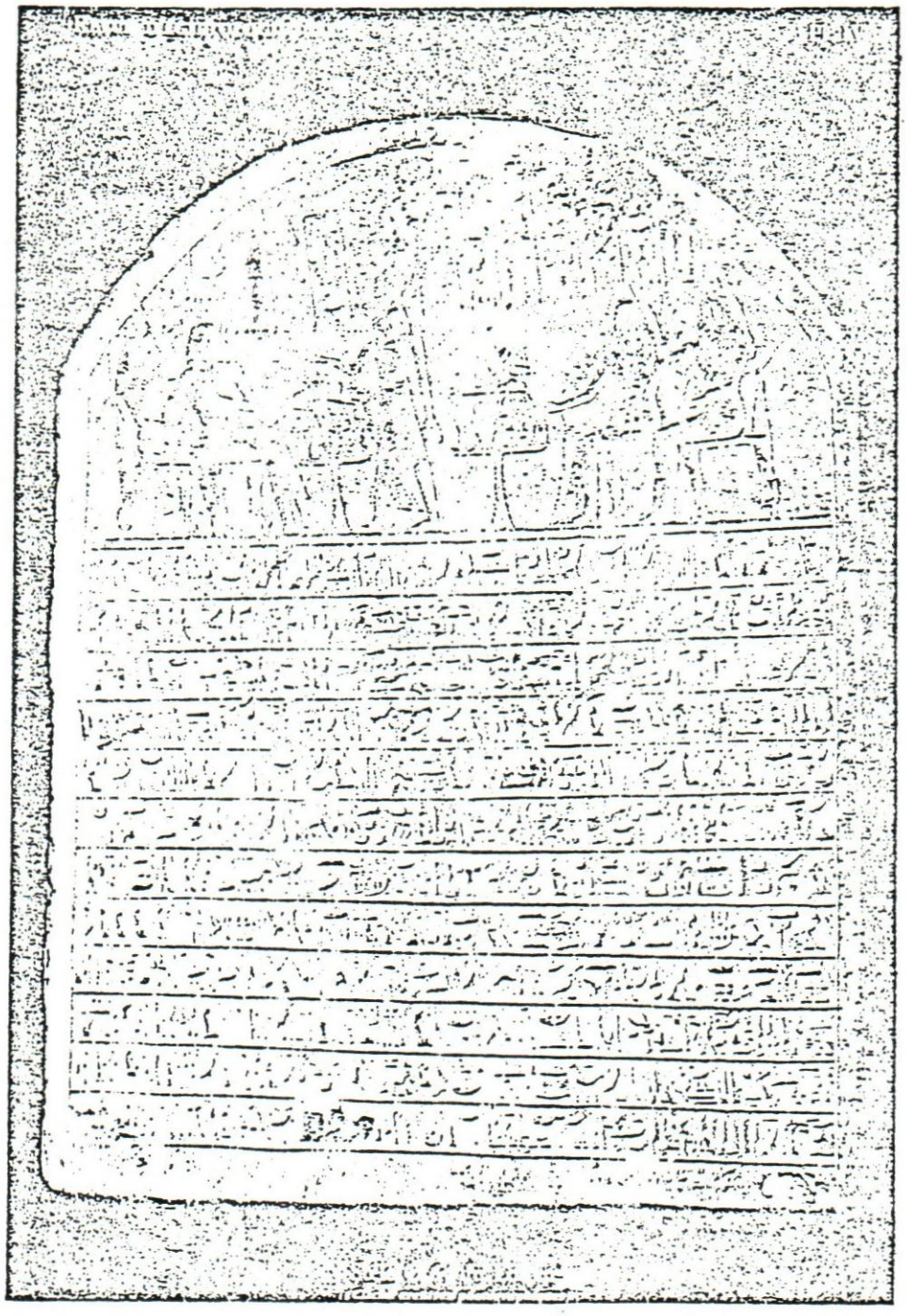


Figure 50*a*.

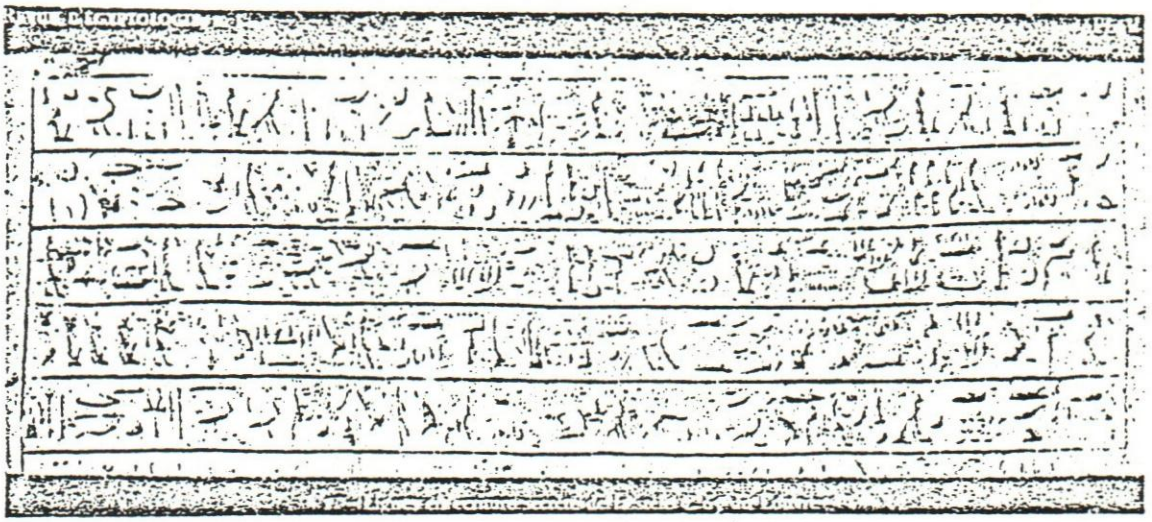


Figure 50*b*.

Could it be that installment-plan buying was rampant in Ancient Egypt too, so that people didn't have enough left to pay their taxes?

Now, let's go back to those cryptographic hieroglyphics mentioned a moment ago. Here, in Fig. 50*a* for instance, is a picture of an inscription on a stela now in the Louvre, in Paris. Lines 6–10, inclusive, below the seated figures under the arch, contain secret writing in hieroglyphics; in Fig. 50*b*, these lines are seen enlarged. I won't attempt to explain the nature of the cryptography involved. It's pretty simple—something like the sort of cryptography involved in our own type of rebuses, and in our modern acronymic abbreviations, such as CARE, which stands for Cooperative (for) American Relief Everywhere, or NASA, for the National Aeronautics (and) Space Administration.

The following extracts, translated from a long article by Prof. Étienne Drioton in "Revue D'Égyptologie," Paris, 1933, will be of interest (p. 1):

> "From the time of the Middle Empire onwards, Egypt had, alongside the official and normal system of writing, a tradition of cryptographic writing, the oldest known examples of which are to be found in the tombs of Beni-Hassan, and the most recent in the inscriptions of the temples of the Greco-Roman epoch.
>
> • • • • • • • •
>
> (p. 32):
>
> It is necessary to add to the enumeration of the cryptographic procedures the variation in the appearance of the cryptographic signs themselves . . . . This variation, without however affecting their value, can (1) modify the appearance of the signs; (2) affect their position in various ways; and (3) combine these signs with others. . . . Finally, to note a last peculiarity of these inscriptions which, because of their fine form, deserve to be considered the classics of the cryptography of this period, the scribe has several times successfully carried out in them what was doubtless considered to be the triumph of the genre: the grouping of signs which offer a possible but fallacious meaning in clear, alongside a cryptographic meaning which is the only true one."
>
> • • • • • • • •

And now for the most intriguing explanation offered by Drioton as to why cryptography was incorporated in these inscriptions. You know quite well why cryptography is employed in military, diplomatic, banking, and industrial affairs; you also know perhaps that it is used for other purposes, in love affairs, for example, and in illicit enterprises of all sorts; and you probably also know that it is often used for purposes of amusement and diversion, in tales of mystery, in the sorts of things published in newspapers and literary journals—they are called "crypts." But none of these explanations will do for the employment of cryptography in Egyptian hieroglyphics. Here's what Drioton thinks:

(p. 50):

"There remains, therefore, the supposition that, far from seeking to prevent reading, the cryptography in certain passages of these inscriptions was intended to encourage their reading.

The appeals which often introduce formulae of this type, and which are addressed to all visitors to the tombs, show in fact how much the Egyptians desired to have them read, but also, by the very fact of their existence, what an obstacle they encountered in the indifference, not to say satiety, produced by the repetition and the monotony of these formulae. To attempt to overcome this indifference by offering a text whose appearance would pique curiosity, based on the love, traditional in Egypt, for puzzles, to get people to decipher, with great difficulty, what was desired they should read, such is perhaps, in last analysis, the reason why the three monuments of the period of Amenophis III here considered present certain passages in cryptography.

One must suppose, in this case, that the goal was not attained and that it was very quickly seen that the expedient produced, on the apathy of the visitors, an effect opposite to that intended: it removed even the slightest desire to read the inscriptions presented in this form. The new procedure was therefore—the monuments seem to prove it—abandoned as soon as it had been tried."

* * * * * * *

Before leaving the story of Champollion's mastery of Egyptian hieroglyphic writing, I think I should re-enact for you as best I can in words what he did when he felt he'd really reached the solution to the mystery. I'll preface it by recalling to you what Archimedes is alleged to have done when he solved a problem he'd been struggling with for some time. Archimedes was enjoying the pleasures of his bath and was just stepping out of the pool when the solution of the problem came to him like a flash. He was so overjoyed that he ran, naked, through the streets shouting "Eureka! I've found it, I've found it." Well, likewise, when young Champollion one day had concluded he'd solved the mystery of the Egyptian heiroglyphics, he set out on a quick mile-run to the building where his lawyer brother worked, stumbled into his brother's office, shouting "Eugene, I did it!", and flopped down to the floor in a trance where he is said to have remained immobile and completely out for five days. "Champollion died on 4 March 1832, leaving behind the manuscript of an *Egyptian Grammar* and of a *Hieroglyphic Dictionary* which, except for some errors of details inevitable in a gigantic work of decipherment and easily correctable, form the basis of the entire science of Egyptology."[1]

I shouldn't leave this brief story of the cryptanalytic phases of the solution of the Egyptian hieroglyphic writing without telling you that there remain plenty of other sorts of writings which some of you may want to try your hand at deciphering when you've learned some of the principles and procedures of the science of cryptology. A list of thus-far undeciphered writings was drawn up for me by Professor Alan C. Ross, of London University, in 1945, and had 19 of them. Since 1945 only two have been deciphered, Minoan Linear A and Linear B writing. The Easter Island writing is said to have very recently been solved, but I'm not sure of that. There are some, maybe just a very few, who think the hieroglyphic writing of the ancient Maya Indians of Central America may fall soon, but don't be too sanguine about that either.

Should any of you be persuaded to tackle any of the still undeciphered writings in the list drawn up by Professor Ross, be sure you have an authentic case of an undeciphered language before you. Figure 16 is one that was written on a parchment known as the Michigan Papyrus. It had baffled certain savants who had a knowledge of Egyptology and attempted to read it on the theory that it was some sort of variation—a much later modification—of Egyptian hieroglyphic writing. These old chaps gave it up as a bad job. Not too many years ago, it came to the attention of a young man who knew very little about Egyptian hieroglyphics. He saw it only as a simple substitution cipher on some old language. He tackled the Michigan Papyrus on that basis and solved it. He found the language to be early Greek. And what was the purport of the writing? Well, it was a wonderful old Greek beautician's secret formula for further beautifying lovely Greek young women—maybe the bathing beauties of those days, among whom possibly were "Miss Greece of 500 B. C." and "Miss Universe" of those days!

[1] Drioton, "*Decipherment of Egyptian Hieroglyphics*," La Science Moderne, August 1924, pp. 423–432.

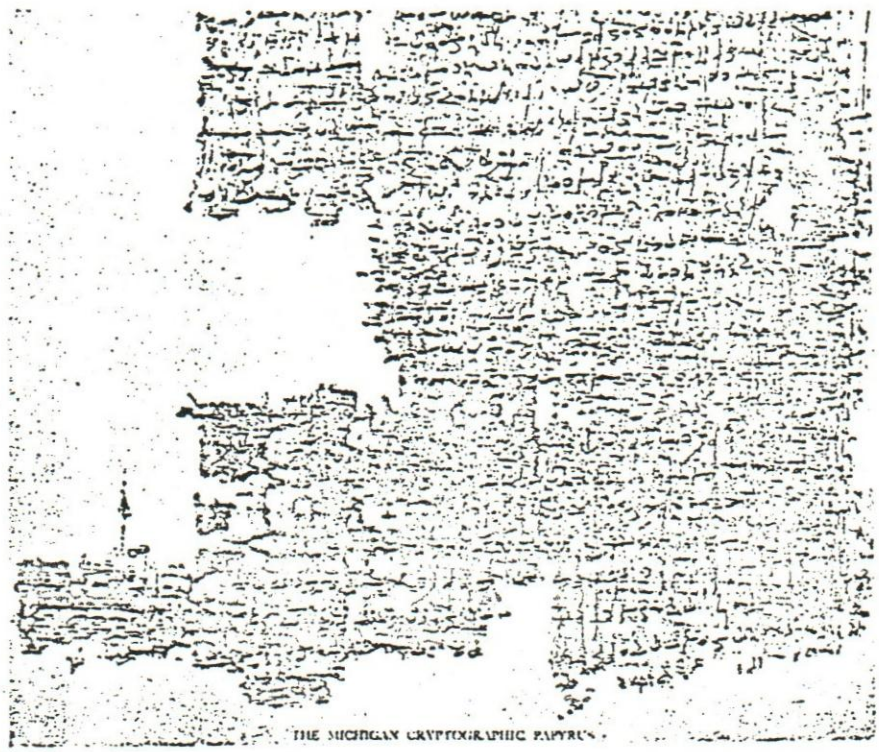


Figure 51.

The next period of importance in this brief account of the history of cryptology is the one which deals with the codes and ciphers used by the contestants in our Civil War, the period 1861-65. It is significant and important because, for the first time in history, rapid and secure communications on a large scale became practicable in the conduct of organized warfare and world-wide diplomacy. They became practicable when cryptology and telegraphy were joined in happy, sometimes contentious, but long-lasting wedlock.

There is one person I should mention, however, before coming to the period of the Civil War in U. S. history. I refer here to Edgar Allan Poe, who in 1842 or thereabouts, kindled an interest in cryptography in newspapers and journals of the period, both at home and abroad. For his day he was certainly the best informed person in this country on cryptologic matters outside of the regular employees of Government departments interested in the subject.

In regard to Poe, one of our early columnists, there's an incident I'd like to tell you about in connection with a challenge he printed in one of his columns, in which he offered to solve any cipher submitted by his readers. He placed some limitations on his challenge, which amounted to this—that the challenge messages should involve but a single alphabet. In a later article Poe tells about the numerous challenge messages sent him and says: "Out of perhaps 100 ciphers altogether received, there was only one which we did not immediately succeed in resolving. This one we demonstrated to be an imposition—that is to say, we fully proved it a jargon of random characters, having no meaning whatever." I wish that cipher had been preserved for posterity, because it would be interesting to see what there was about it that warranted Poe to state that "we fully proved it a jargon of random characters." Maybe I'm not warranted in saying of this episode that Poe reminds me of a ditty sung by a character in a play put on by some undergraduates of one of the colleges of Cambridge University, in England. At a certain point in the play, this character steps to the front of the stage and sings:

"I am the Master of the College,
What I don't know ain't knowledge."

Thus, Poe. What he couldn't solve, he assumed wasn't a real cipher—a very easy out for any cryptologist up against something tough.

If any of you are interested sufficiently to wish to learn something about Poe's contributions to cryptology, I refer you to a very fine article by Professor W. K. Wimsatt, Jr., entitled "What Poe Knew About Cryptography," Publications of the Modern Language Association of America, New York, Vol. LVIII, No. 3, September 1943, pp 754-79. In it you'll find references to what I have published on the same subject.

This completes the third lecture in this series. In the next one we shall come to that interesting period in cryptologic history in which codes and ciphers were used in this country in the War of the Rebellion, the War Between the States, the Civil War—you use your own pet designation for that terrible and costly struggle.

Lecture IV

A detailed account of the codes and ciphers of the Civil War in the United States of America can hardly be told without beginning with a bit of biography about the man who became the first signal officer in history and the first Chief Signal Officer of the United States Army, Albert J. Myer, the man in whose memory that lovely little U. S. Army post adjacent to Arlington

BRIGADIER GENERAL ALBERT J. MYER

Figure 52.

Cemetery was named. Myer was born on 20 September 1827, and after an apprenticeship in the then quite new science of electric telegraphy he entered Hobart College, Geneva, New York, from which he was graduated in 1847. From early youth he had exhibited a predilection for artistic and scientific studies, and upon leaving Hobart he entered Buffalo Medical College, receiving the M.D. degree four years later. His graduation thesis, "A Sign Language for Deaf Mutes," contained the germ of the idea he was to develop several years later, when, in 1854, he was commissioned a 1st Lieutenant in the Regular Army, made an Assistant Surgeon, and ordered to New Mexico for duty. He had plenty of time at this far away outpost to think about developing an efficient *system* of military "aerial telegraphy," which was what visual signaling was then called. I emphasize the word "system" because, strange to say, although instances of the use of lights and other visual signals can be found throughout the history of warfare, and their use between ships at sea had been practiced by mariners for centuries, yet down to the middle of the 19th Century surprisingly little progress had been made in developing methods and instruments for the *systematic* exchange of military information and instructions by means of signals of any kind. Morse's practical system of electric telegraphy, developed in the years 1832-35, served to focus attention within the military upon systems and methods of intercommunication by means of both visual and electrical signals. In the years

immediately preceding the Civil War, the U. S. Army took steps to introduce and to develop system of visual signaling for general use in the field. It was Assistant Surgeon Myer who furnished the initiative in this matter.

In 1856, two years after he was commissioned assistant surgeon, Myer drafted a memorandum on a new system of visual signaling and obtained a patent on it. Two years later, a board was appointed by the War Department to study Myer's system. It is interesting to note that one of the officers who served as an assistant to Myer in demonstrating his system before the board was a Lieutenant E. P. Alexander, Corps of Engineers. We shall hear more about him presently, but at the moment I will say that on the outbreak of war, Alexander organized the Confederate Signal Corps. After some successful demonstrations by Myer and his assistants, the War Department fostered a bill in Congress, which gave its approval to his ideas. But what is more to the point, Congress appropriated an initial amount of $2,000 to enable the Army and the War Department to develop the system. The money, as stated in the Act was to be used "for manufacture or purchase of apparatus and equipment for field signaling." The act also contained another important provision: it authorized the appointment, on the Army staff, of one Signal Officer with the rank, pay, and allowances of a major of cavalry. On 2 July 1860, "Assistant Surgeon Albert J. Myer (was appointed) to be Signal Officer, with the rank of Major, 27 June 1860, to fill an original vacancy," and two weeks later Major Myer was ordered to report to the Commanding General of the Department of New Mexico for signaling duty. The War Department also directed that two officers be detailed as his assistants. During a several months' campaign against hostile Navajos, an extensive test of Myer's new system, using both flags and torches, was conducted with much success. In October 1860, a Lieutenant J. E. B. Stuart, later to become famous as a Confederate cavalry leader, tendered his services to aid in signal instruction.

Less than a year after Major Myer was appointed as the first and, at that time, the only Signal Officer of the U. S. Army, Fort Sumter was attacked and, after a 36-hour bombardment, surrendered. The bloody four-year war between the North and the South began. The date was 14 April 1861. Myer's system of aerial telegraphy was soon to undergo its real baptism under fire, rather than by fire. But with the outbreak of war, another new system of military signal communication, signaling by the electric telegraph, began to undergo its first thorough test in combat operations. This in itself is very important in the history of cryptology. But far more significant in that history is a fact that I mentioned at the close of the last lecture, *viz*, that for the first time in the conduct of organized warfare, *rapid and secret military communications on a large scale became practicable*, because cryptology and electric telegraphy were now to be joined in a lasting wedlock. For when the war began, the electric telegraph had been in use for less than a quarter of a century. Although the first use of electric telegraphy in military operations was in the Crimean War in Europe (1854–56), its employment was restricted to communications exchanged among headquarters of the Allies, and some observers were very doubtful about its utility even for this limited usage. It may also be noted that in the annals of that war there is no record of the employment of electric telegraphy together with means for protecting the messages against their interception and solution by the enemy.

On the Union side in the Civil War, military signal operations began with Major Myer's arrival in Washington on 3 June 1861. His basic equipment consisted of kits containing a white flag with a red square in the center for use against a dark background; a red flag with a white square for use against a light background; and torches for night use. It is interesting to note that these are the elements which make up the familiar insignia of our Army Signal Corps. The most pressing need which faced Major Myer was to get officers and men detailed to him wherever signals might be required, and to train them in what had come to be called the "wigwag system,"[1] the motions of which are depicted in Fig. 53. This training included learning something about codes and ciphers and gaining experience in their usages.

[1] And, of course, the G. I.'s of those days had a pet name for the users of the system. They called them "flag floppers."

But there was still no such separate entity as a Signal Corps of the Army. Officers and enlisted men were merely detailed for service with Major Myer for signaling duty. It was not until two years after the war started that the Signal Corps was officially established and organized as a separate branch of the Army, by appropriate Congressional action.

In the meantime, another signaling organization was coming into being—an organization which was an outgrowth of the government's taking over control of the commercial telegraph companies in the United States on 25 February 1862. There were then only three in number:

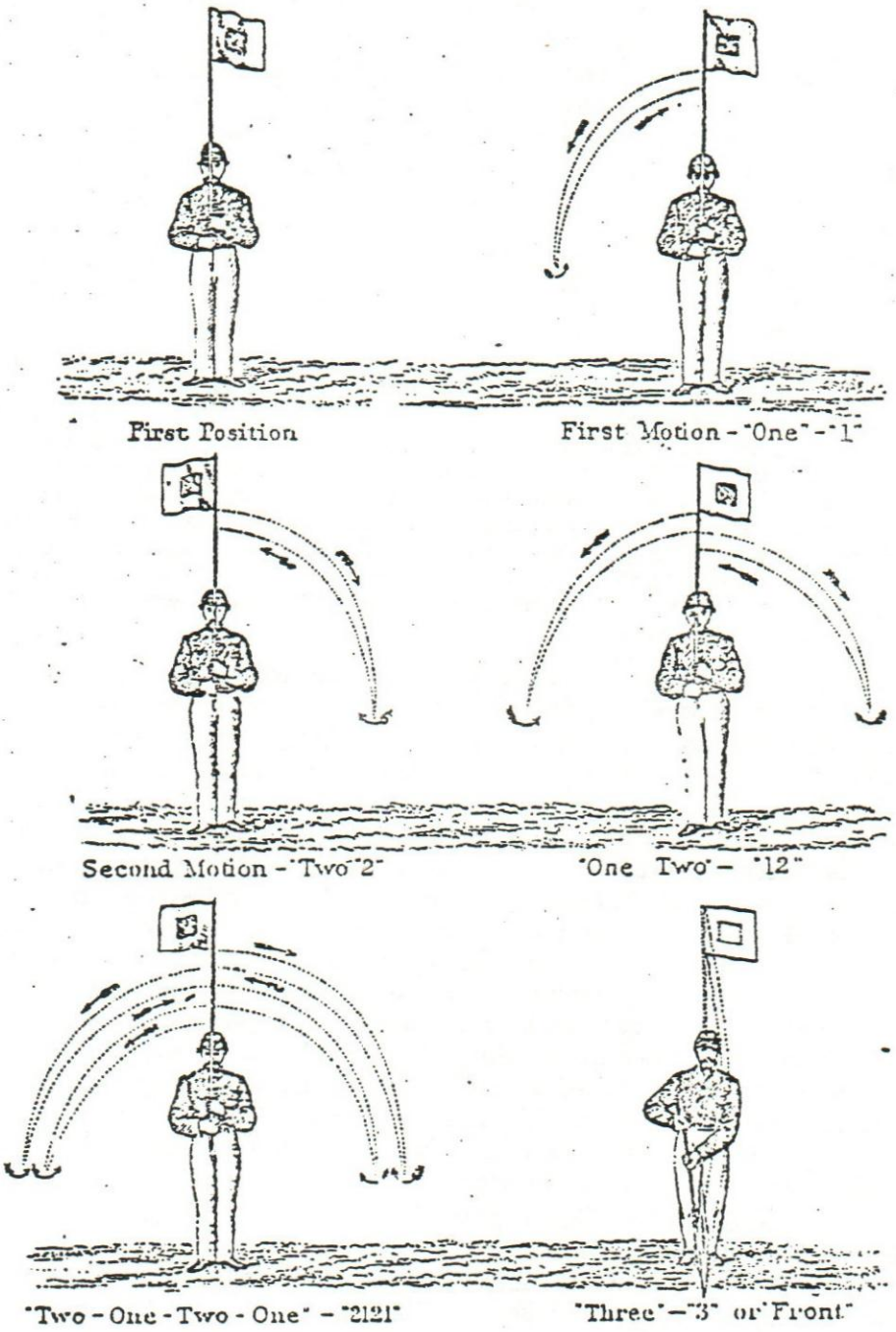


Figure 53.

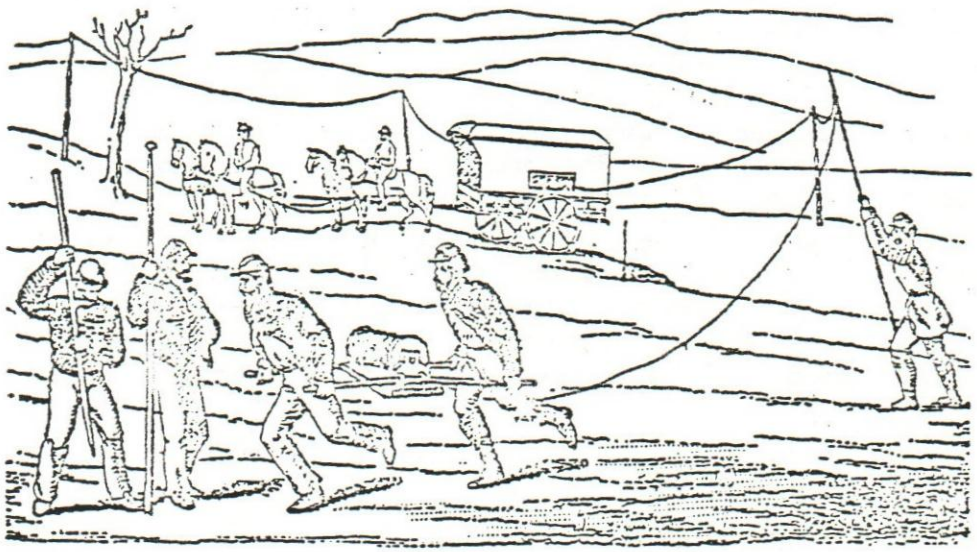
the American, the Western Union, and the Southwestern. The telegraph lines generally followed the right-of-way of the railroads. The then Secretary of War, Simon Cameron, sought the aid of Thomas A. Scott, of the Pennsylvania Railroad, who brought some of his men to Washington for railroad and telegraphic duties with the Federal Government. From a nucleus of four young telegraph operators grew a rather large military telegraph organization which was not given formal status until on 28 October 1861 President Lincoln gave Secretary Cameron authority to set up a "U. S. Military Telegraph Department" under a man named Anson Stager, who, as general superintendent of the Western Union, was called to Washington, commissioned a captain (later a colonel) in the Quartermaster Corps, and made superintendent of the Military Telegraph Department. Only about a dozen of the members of the Department became commissioned officers, and they were made officers so that they could receive and disburse funds and property; all the rest were civilians. The U. S. Military Telegraph "Corps," as it soon came to be designated, without warrant, was technically under Quartermaster General Meigs, but for all practical purposes it was under the immediate and direct control of the Secretary of War, a situation admittedly acceptable to Meigs. There were now two organizations for signaling in the Army, and it was hardly to be expected that no difficulties would ensue from the duality. In fact, the difficulties began very soon, as can be noted in the following extract from a lecture before the Washington Civil War Round Table, early in 1954, by Dr. George R. Thompson, Chief of the Historical Division of the Office of the Chief Signal Officer of the U. S. Army:

> The first need for military signals arose at the important Federal fortress in the lower Chesapeake Bay at Fort Monroe. Early in June, Myer arrived there, obtained a detail of officers and men and began schooling them. Soon his pupils were wig-wagging messages from a small boat, directing fire of Union batteries located on an islet in Hampton Roads against Confederate fortifications near Norfolk. Very soon, too, Myer began encountering trouble with commercial wire telegraphers in the area. General Ben Butler, commanding the Federal Department in southeast Virginia, ordered that wire telegraph facilities and their civilian workers be placed under the signal officer. The civilians, proud and jealous of their skills in electrical magic, objected in no uncertain terms and shortly an order arrived from the Secretary of War himself who countermanded Butler's instructions. The Army signal officer was to keep hands off the civilian telegraph even when it served the Army.

I have purposely selected this extract from Dr. Thompson's presentation because in it we can clearly hear the first rumblings of that lengthy and acrimonious feud between two signaling organizations whose uncoordinated operations and rivalry greatly reduced the efficiency of all signaling operations of the Federal Army. As already indicated, one of these organizations was the U. S. Military Telegraph "Corps," hereinafter abbreviated as the USMTC, a civilian organization which operated the existing commercial telegraph systems for the War Department, under the direct supervision of the Secretary of War, Edwin M. Stanton. The other organization was, of course, the infant Signal Corps of the United States Army, which was not yet even established as a separate Branch, whereas the USMTC had been established in October 1861, as noted above. Indeed, the Signal Corps had to wait until March 1863, *two years after the outbreak of war*, before being established officially. In this connection it should be noted that the Confederate Signal Corps had been established a full year earlier, in April 1862. Until then, as I've said before, for signaling duty on both sides, there were only officers who were individually and specifically detailed for such duty from other branches of the respective Armies of the North and the South. Trouble between the USMTC and the Signal Corps of the Union Army began when the Signal Corps became interested in signaling by electric telegraphy and began to acquire facilities therefor.

As early as in June 1861, Chief Signal Officer Myer had initiated action toward acquiring or obtaining electrical telegraph facilities for use in the field, but with one exception nothing happened. The exception was in the case of the episode in the military department in southeast Virginia, commanded by General Benjamin Butler, an episode that clearly foreshadowed the future road for the Signal Corps in regard to electrical signaling: the road was to be closed and barred. In August 1861, Colonel Myer tried again and in November of the same year he

recommended in his annual report that $30,000 be appropriated to establish an electric signaling branch in the Signal Corps. The proposal failed to meet the approval of the Secretary of War. One telegraph train, however, which had been ordered by Myer many months before, was delivered in January 1862. The train was tried out in an experimental fashion, and under considerable difficulties, the most disheartening of which was the active opposition of persons in Washington, particularly the Secretary of War. So, for practically the whole of the first two years of the war, signal officers on the Northern side had neither electrical telegraph facilities nor Morse operators—they had to rely entirely on the wig-wag system. However, by the middle of 1863 there were thirty "flying telegraph" trains in use in the Federal Army. Here's a picture of such a train. The normal length of field telegraph lines was five to eight miles, though in some cases the instruments had worked at distances as great as twenty miles. But even before the Signal Corps began to acquire these facilities, there had been agitation to have them, as well as their Signal Corps operating personnel, all turned over to the USMTC, which had grown into a tightly knit organization of over 1,000 men and had become very influential in Washington, especially by virtue of its support from Secretary of War Stanton. As a consequence, the USMTC had its way. In the fall of 1863, it took over all the electric telegraph facilities and telegraph operators of the Signal Corps. Colonel Myer sadly wrote: "With the loss of its electric lines the Signal Corps was crippled."



A drawing from Myer's *Manual of Signals* illustrating the field, or flying, telegraph. It shows the wagon with batteries and instruments. The wire (in this case presumably bare copper, since it is being strung on insulators on poles) is being run out from a reel carried by two men. The linesmen are using a crowbar to open holes to receive the lance poles. Myer estimated that 2½ miles of such wire line could be put up in an hour.

Figure 54.

So now there were two competing signal organizations on the Northern side: The U. S. Army's Signal Corps, which was composed entirely of military personnel with no electric telegraph facilities (but was equipped with means for visual signaling), and the USMTC, which was not a part of the Army, being staffed almost entirely with civilians, and which had electric telegraph facilities and skilled Morse operators (but no means or responsibilities for visual signaling or "aerial telegraphy" which, of course, was old stuff). "Electric telegraphy" was now *the* thing. The USMTC had no desire to share electric telegraphy with the Signal Corps, a determination in which it was most ably assisted by Secretary of War Stanton, for reasons that fall outside the scope of the present lecture.

However, from a technical point of view it is worth going into this rivalry just a bit, if only to note that the personnel of both organizations, the military and the civilian, were not merely signalmen and telegraph operators: they served also as cryptographers and were therefore entrusted with the necessary cipher books and cipher keys. Because of this, they naturally became privy to the important secrets conveyed in cryptographic communications and they therefore enjoyed status as VIP's. This was particularly true of members of the USMTC, because they, and only they, were authorized to be custodians and users of the cipher books. Not even the commanders of the units they served had access to them. For instance, on the one and only occasion when General Grant forced his cipher operator, a civilian named Beckwith, to turn over the current cipher book to a colonel on Grant's staff, Beckwith was immediately discharged by the Secretary of War and Grant was reprimanded. A few days later, Grant apologized and Beckwith was restored to his position. But Grant never again demanded the cipher book held by his telegraph operator.

The Grant-Beckwith affair alone is sufficient to indicate the lengths to which Secretary of War Stanton went to retain control over the USMTC, including its cipher operators, and its cipher books. In fact, so strong a position did he take that on 10 November 1863, following a disagreement over who should operate and control all the military telegraph lines, Myer, by then full Colonel, and bearing the imposing title "Chief Signal Officer of the United States Army," a title he had enjoyed for only two months, was peremptorily relieved from that position and put on the shelf. Not long afterward, and for a similar reason, Myer's successor, Lieutenant Colonel Nicodemus, was likewise summarily relieved as Chief Signal Officer by Secretary Stanton; indeed, he was not only removed from that position—he was "dismissed from the Service." Stanton gave "phoney" reasons for dismissing Colonel Nicodemus, but I am glad to say that the latter was restored his commission in March 1865, by direction of the President; also by direction of the President, Colonel Myer was restored to his position as Chief Signal Officer of the U. S. Army on 25 February 1867.

When Colonel Myer was relieved from duty as Chief Signal Officer in November 1863, he was ordered to Cairo, Illinois, to await orders for a new assignment. Very soon thereafter he was either designated (or he may have himself decided) to prepare a field manual on signaling and there soon appeared, with a prefatory note dated January 1864, a pamphlet of 148 pages, a copy of which is now in the Rare Book Room of the Library of Congress. The title page reads as follows:

> "*A Manual of Signals: for the use of signal officers in the field.* By Col. Albert J. Myer, Signal Officer of the Army, Washington, D. C., 1864."

Even in this first edition, printed on an Army press, Myer devoted nine pages to a reprint of an article from *Harper's Weekly* entitled "Curiosities of Cipher," and in the second edition, 1866, he expanded the section on cryptography to sixty pages. More editions followed and I think we may well say that Myer's *Manual*, in its several editions, was the pioneer American text on military signaling. But I'm sorry to say that as regards cryptology it was rather a poor thing. Poe had done better twenty years before that in his essay entitled "A few words on secret writing."

Because of its historic nature, you may like to see what Myer's original "wig-wag code" was like. It was called "a two-element code" because it employed only two digits, 1 and 2, in permutations of 1, 2, 3 and 4 groups. For example, A was represented by the permutation 22; B, by 2122; and C, by 121, etc. In flag signaling, a "1" was indicated by a motion to the left, and a "2" by a motion to the right. Later these motions were reversed, for reasons which must have been good but are now not obvious.[2] Here is Myer's two-element code which continued to be used until 1912:

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[2] This reversal can be seen in Fig. 53.

A - 22	M - 1221	Y - 111	
B - 2122	N - 11	Z - 2222	
C - 121	O - 21	& - 1111	
D - 222	P - 1212	ing - 2212	
E - 12	Q - 1211	tion - 1112	
F - 2221	R - 211		
G - 2211	S - 212	End of word	- 3
H - 122	T - 2	End of sentence	- 33
I - 1	U - 112	End of message	- 333
J - 1122	V - 1222	Affirmative	- 22.22.22.3
K - 2121	W - 1121	Repeat	- 121.121.121
L - 221	X - 2122	Error	- 212121

Note: No. 3 (end of word) was made by a forward downward motion, called "front." There were about a dozen more signals, for numerals, for frequently used short sentences, etc.

We must turn our attention now to the situation as regards the organization for signaling in the Confederate Army. It is of considerable interest to note that in the first great engagement of the War, that of the first Bull Run battle, the Confederate Signal Officer was that young Lieutenant, E. P. Alexander, who had assisted in demonstrating the wig-wag system before a board appointed by the War Department to study Myer's system. Alexander, now a Captain in grey, used Myer's system during the battle, which ended in disaster for the Union forces; and it is said that Alexander's contribution by effective signaling was an important factor in the Confederate victory. Dr. Thompson, whom I have quoted before, says of this battle:

> "Thus the fortunes of war in this battle saw Myer's system of signals succeed, ironically, on the side hostile to Myer. Because of general unpreparedness and also some disinterest and ignorance, the North had neither wig-wag signals nor balloon observations."

The only communication system which succeeded in signal work for the Union Army was the infant USMTC. But the Confederate system under Alexander, off to a good start at Bull Run, throughout the war operated with both visual and electric telegraphy, and the Confederates thought highly enough of their signal service to establish it on an official basis, on 19 April 1862, less than a year after that battle. Thus, although the Confederate Signal Corps never became a distinct and independent branch of the Army as did the Union Signal Corps, it received much earlier recognition from the Confederate Government than did the Signal Corps of the Federal Government. Again quoting Dr. Thompson:

> "The Confederate Signal Corps was thus established nearly a year earlier than its Federal counterpart. It was nearly as large, numbering some 1,500, most of the number, however, serving on detail. The Confederate Signal Corps used Myer's system of flags and torches. The men were trained in wire telegraph, too, and impressed wire facilities as needed. But there was nothing in Richmond or in the field comparable to the extensive and tightly controlled civilian military telegraph organization which Secretary Stanton ruled with an iron hand from Washington."

We come now to the codes and ciphers used by both sides in the war, and in doing so we must take into consideration the fact that on the Union side, there were, as I have indicated, two separate organizations for signal communications; one for visual signaling, the other for electric. We should therefore not be too astonished to find that the cryptosystems used by the two competing organizations were different. On the other hand, on the Confederate side, as just noted, there was only one organization for signal communications, the Signal Corps of the Confederate States Army, which used both visual and electric telegraphy, the latter facilities being taken over and employed when and where they were available. There were reasons for this marked difference between the way in which the Union and the Confederate signal operations were organized and administered but I do not wish to go into them now. One reason, strange to say, had to do with the difference between the cryptocommunication arrangements in the Union and in the Confederate Armies.

We will discuss the cryptosystems used by the Federal Signal Corps first and then those of the Confederate Signal Corps. Since both corps used visual signals as their primary means, we find them employing Myer's visual-signaling code shown above. At first both sides sent unenciphered messages; but soon after learning that their signals were being intercepted and were being read by the enemy, each side decided to do something to protect its messages. Initially both decided on the same artifice, *viz*, changing the visual-signaling equivalents for the letters of the alphabet, so that, for instance, "22" was not always "A", etc. This sort of changing-about of values soon became impractical, since it prevented memorizing the wig-wag equivalents once and for all. The difficulty in the Union Army's Signal Corps was solved by the introduction into usage of a cipher disk invented by Myer himself. A full description of the disk in its various embodiments will be found in Myer's *Manual*, but here's a picture of three forms of it. You can see how readily the visual wig-wag equivalents for letters, figures, etc., can be changed according to some pre-arranged indicator for juxtaposing concentric disks. In my Fig. 55 the top left disks (Fig. 1 of Myer's Plate XXVI) show that the letter A is represented by 112, B, by 22, etc. By moving the two circles to a different juxtaposition a new set of equivalents will be established. Of course, if the setting is kept fixed for a whole message the encipherment is strictly monoalphabetic; but Myer recommends changing the setting in the middle of the message or, more specifically, at the end of each word, thus producing a sort of polyalphabetic cipher which would delay solution a bit. An alternative way, Myer states, would be to use what he called a "countersign word," but which we call a *key word*, each letter of which would determine the setting of the disk or for a single word or for two consecutive words, etc. Myer apparently did not realize that retaining or showing externally, that is, in the cipher text, the lengths of the words of the plain text very seriously impairs the security of the cipher message. A bit later we shall discuss the security afforded by the Myer disk in actual practice.

In the Confederate Signal Corps, the system used for encipherment of visual signals was apparently the same as that used for enciphering telegraphic messages, and we shall soon see what it was. Although Myer's cipher disk was captured a number of times, it was apparently disdained by the Confederates, who preferred to use a wholly different type of device, as will be described presently, for both visual and electric telegraphy.

So much for the cryptosystems used in connection with visual signals by the Signal Corps of both the North and the South, systems which we may designate as "tactical ciphers." We come now to the systems used for what we may call "strategic ciphers," because the latter were usually exchanged between the seat of Government and field commanders, or among the latter. In the case of these communications the cryptosystems employed by each side were quite different.

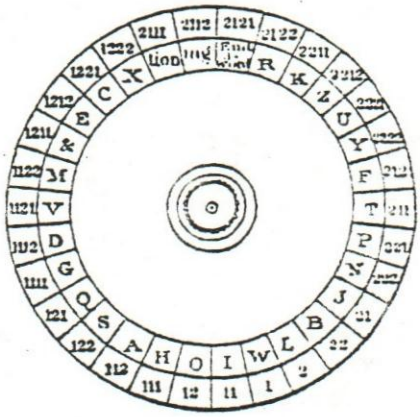
On the Northern side the USMTC used a system based upon what we now call transposition but in contemporary accounts they were called "route ciphers" and that name has stuck. The designation isn't too bad, because the processes of encipherment and decipherment, though dealing not with the individual letters of the message but with entire words, involves following the prescribed paths or routes in a diagram in which the message is written. I know no simpler or more succinct description of the route cipher than that given by one of the USMTC operators, J. E. O'Brien, in an article in *Century Magazine*, XXXVIII, September 1889, entitled "Telegraphing in Battle":

> "The principle of the cipher consisted in writing a message with an equal number of words in each line, then copying the words up and down the columns by various routes, throwing in an extra word at the end of each column, and substituting other words for important names and verbs."

A more detailed description in modern technical terms would be as follows: A system in which in encipherment the *words* of the plaintext message are inscribed within a matrix of a specified number of rows and columns, inscribing the words within the matrix from left to right, in successive lines and rows downward as in ordinary writing, and taking the words out of the matrix, that is, transcribing them, according to a prearranged route to form the cipher message.

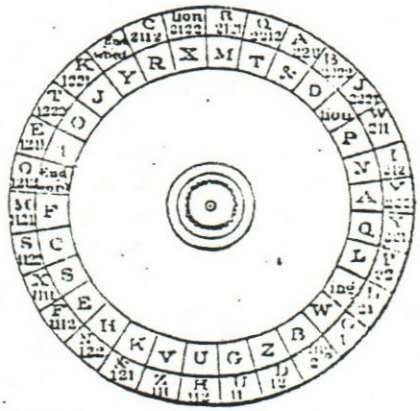
The specific routes to be followed were set forth in numbered booklets, each being labeled "War Department Cipher" followed by a number. In referring to them hereinafter I shall use the term "cipher books," or sometimes, more simply, the term "ciphers," although the cryptosystem involves both cipher and code processes. It is true that the basic principle of the system, that of transposition, makes the system technically a cipher system as defined in our modern terminology; but the use of "arbitraries," as they were called, that is, words arbitrarily assigned to represent the names of persons, geographic points, important nouns and verbs, etc., makes the system technically a code system as defined in our modern terminology.

Figure 1.



Two Discs.

Figure 2.

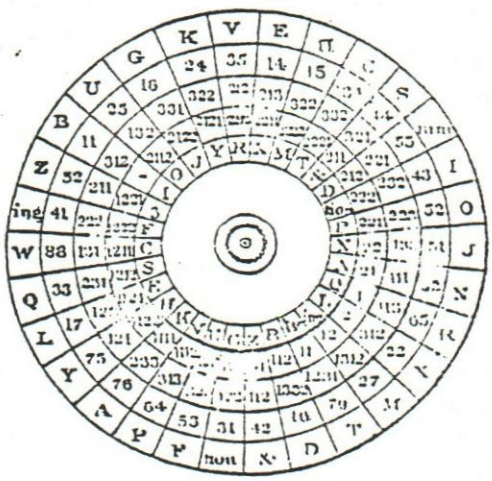


Two Discs.

Vertical Section

Figure 3.

Figure 4.



Plan for Service Discs.

Figure 5.

Vertical Section exhibiting plan for four Discs.

Figure 55.

There were in all about a dozen cipher books used by the USMTC throughout the war. For the most part they were employed consecutively, but, it seems that sometimes two different ones were employed concurrently. They contained not only the specific routes to be used but also indicators for the routes and for the sizes of the matrices; and, of course, there were lists of code words, with their meanings. These route ciphers were supposed to have been the invention of Anson Stager, whom I have mentioned before in connection with the establishment of the USMTC, and who is said to have first devised such ciphers for General McClellan's use in West Virginia, in the summer of 1861, before McClellan came to Washington to assume command of the Army of the Potomac.

Anson Stager and many others thought that he was the original inventor of the system, but such a belief was quite in error because word-transposition methods similar to Stager's were in use hundreds of years before his time. For instance, in 1685, in an unsuccessful attempt to invade Scotland, in a conspiracy to set the Duke of Monmouth on the throne, Archibald Campbell, 9th Earl of Argyll, suffered an unfortunate "accident." He was taken prisoner and beheaded by order of James the Second. The communications of the poor Earl were not secure, and when they fell into government hands they were soon deciphered. The method Argyll used was that of word transposition, and if you are interested in reading a contemporary account of how it was solved, look on pages 56–59 of that little book I mentioned before as being one of the very first books in English dealing with the subject of cryptology, that by James Falconer, entitled *Cryptomenysis Patefacta: Or the Art of Secret Information Disclosed Without a Key*, published in London in 1685. There you will find the progenitor of the route ciphers employed by the USMTC, 180 years after Argyll's abortive rebellion.

The route ciphers employed by the USMTC are fully described in a book entitled *The Military Telegraph during the Civil War*, by Colonel William R. Plum, published in Chicago in 1882. I think Plum's description of them is of considerable interest and I recommend his book to those of you who may wish to learn more about them, but they are pretty much all alike. If I show you one example of an actual message and explain its encipherment and decipherment I will have covered practically the entire gamut of the route ciphers used by the USMTC, so basically very simple and uniform were they. And yet, believe it or not, legend has it that the Southern signalmen were unable to solve any of the messages transmitted by the USMTC. This long-held legend I find hard to believe. In all the descriptions I have encountered in the literature not one of them, save the one quoted above from O'Brien, tries to make these ciphers as simple as they really were; somehow, it seems to me, a subconscious realization on the part of Northern writers, usually ex-USMTC operators, of the system's simplicity prevented a presentation which would clearly show how utterly devoid it was of the degree of sophistication one would be warranted in expecting in the secret communications of a great modern army in the decade 1860–1870, three hundred years after the birth of modern cryptography in the papal states of Italy.

Let us take the plain text of a message which Plum (p. 58) used in an example of the procedure in encipherment. The cipher book involved is No. 4 and I happen to have a copy of it so we can easily check Plum's work. Here's the message to be enciphered:

Washington, D. C.
July 15, 1863

For Simon Cameron

I would give much to be relieved of the impression that Meade, Couch, Smith and all, since the battle of Gettysburg, have striven only to get the enemy over the river without another fight. Please tell me if you know who was the one corps commander who was for fighting, in the council of war on Sunday night.

(Signed) A. Lincoln

Plum shows the word-for-word encipherment in a matrix of seven columns and eleven rows.[3] He fails to tell us why a matrix of those dimensions was selected; presumably the selection was made at random, which was certainly permissible. (See Fig. 56.)

Note the seven "nulls" (non significant, or "blind" words) at the tops and bottoms of certain columns, these being added to the cipher text in order to confuse a would-be decipherer. At least that was the theory, but how effective this subterfuge was can be surmised, once it became known that employing nulls was the usual practice. Note also the two nulls (*bless* and *him*) at the end of the last line to complete that line of the matrix. Words in italics are "arbitraries" or code words.

The cipher message is then copied down following the route prescribed by the indicator "BLONDE," as given on page 7 of Cipher Book No. 4 for a message of 11 lines. The indicator could have also been "LINIMENT."

1	2	3	4	5	6	7
(heavy				(county)	(squara)	
(null)				(null)	(null)	
Incubus	*Stewart*	*Brown*	*Norris*	*Knox*	*Madison*	
Wash., D.C.	July	15th	18	60	3	for
sigh	man	Cammer	on	flea	I	wood
Simon	-	Cameron		(period)	I	would
give	much	Toby	*trammeled*	*serenade*	impression	that
give	much	to be	relieved	of the	impression	that
Bunyan	*bear*	*ax*	*cat*	*children*	and	awl
Meade	, (comma)	Couch	, (comma)	Smith	and	all
bat	since	the	*knit*	of	get	ties
, (comma)	since	the	battle	of	Gettys	
large	ass	have	striven	only	to	get
burg	, (comma)	have	striven	only	to	get
village	*skeleton*	*turnip*	without	another	*optic*	*hound*
the enemy	over	the river	without	another	fight	(period)
Please	tell	me	if	you	no	who
Please	tell	me	if	you	know	who
was	the	*Harry*	*Madrid*	*locust*	who	was
was	the	one	corps	commander	who	was
for	*oppressing*	*bitch*	*quail*	*counsel*	of	war
for	fighting	, (comma)	in the	council	of	war
on	*Tyler*	*Rustle*	*upright*	*Adrian*	bless	him
on	Sunday	night	Signature	A. Lincoln	(null)	(null)
	(monkey)	(silk)	(martyr)			(suicide)
	(null)	(null)	(null)			(null)

Figure 56.

To explain the diagram at the top of Fig. 57 I will show you the "Directions for Use" which appear on the reverse side of the title page of "War Department Cipher No. 4," because I am afraid you wouldn't believe me if I merely told you what they say. In Fig. 58 is a picture of the title page and I follow it with Fig. 59, a photograph of what's on its reverse.

Do you imagine that the chap who was responsible for getting this cipher book approved ever thought about what he was doing when he caused those "Directions for Use" to be printed? It doesn't seem possible. All he would have had to ask himself was, "Why put this [illegible] of information in the book itself? Cipher books before this have been captured. Suppose this

[3] Ruled paper was provided to aid in accuracy. In the diagram the upper of each pair of lines [illegible] is the cipher, the lower one, the plain text. Simon Cameron was Lincoln's Secretary of War until [illegible], when he was replaced by Edwin M. Stanton. If this message cited by Plum is authentic, and there is no reason to doubt this, then Cameron was still in friendly contact with Lincoln, possibly as a special observer.

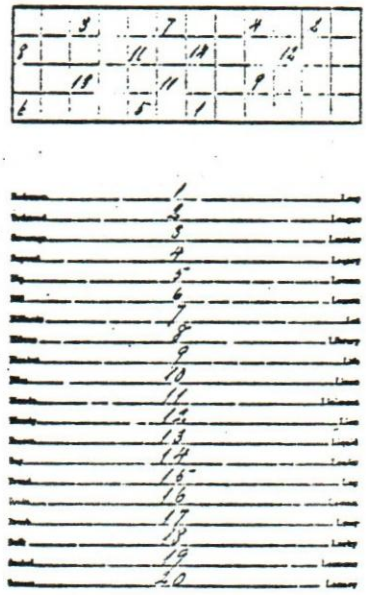


Figure 57.

one falls into enemy hands; can't he read, too, and at once learn about the intended deception? Why go to all the trouble of including "phoney" routes anyway? If the book doesn't fall into enemy hands what good are the "phoney" routes anyway? Why not just indicate the routes in a straight-forward manner, as had been done before? Thus: "Up the 6th column (since "6" is the first number at the left of the diagram), down the 3rd, up the 5th, down the 7th, up the 1st, down the 4th and down the 2nd." This matter is so incredibly fatuous that it is hard to understand how sensible men—and they were sensible—could be so illogical in their thinking processes. But there the "Directions for Use" stand, for all the world to see and to judge.

WAR DEPARTMENT CIPHER NO. 4.

Figure 58.

DIRECTIONS FOR USE.

To find the route, read the figures in the table at top of page from left to right in the order that they occur alternately in the upper and lower lines, the two intermediate lines of figures having no connection with the route, being introduced simply as a blind, the upper line of figures denoting the route *down* the column and the lower line *up*.

EXAMPLE.

See page 14; 7 columns.

Route—Up the 3d; down the 6th; up the 1st; down the 7th; up the 2d; down the 4th; up the 5th.

Commence a cipher with one of the "line indicators," taken from same page as route used, which word must indicate the number of lines in the message. Use two words for more than *twenty* lines.

Figure 59.

Now for the transposition step. The indicator "BLONDE" signifies a matrix of seven columns and eleven rows, with the route set forth above, *viz*, up the 6th column, down the 3rd, etc., so that the cipher text with a "phoney" address and signature,[4] becomes as follows:

TO A. HARPER CALDWELL, Washington, D. C.

Cipher Operator, Army of the Potomac:

Blonde bless of who no optic to get and impression I Madison square Brown cammer Toby ax the have turnip me Harry bitch rustle silk Adrian counsel locust you another only of children serenade flea Knox County for wood that awl ties get hound who was war him suicide on for was please village large bat Bunyan give sigh incubus heavy Norris on trammeled cat knit striven without if Madrid quail upright martyr Stewart man much bear since ass skeleton tell the oppressing Tyler monkey.

(Signed) D. HOMER BATES

Note that the text begins with the indicator "BLONDE." In decipherment the steps are simply reversed. The indicator tells what size matrix to outline; the words beginning "bless of who no optic . . ." are inscribed within the matrix: up the 6th column; then, omitting the "check word" or "null" (which in this case is the word "square") down the 3rd column, etc. The final result should correspond to what is shown in Fig. 56. There then follows the step of interpreting orthographic deviations, such as interpreting "sigh," "man," "cammer," and "on" as Simon Cameron; the word "wood" for "would," etc. The final step reproduces the original plain text.

Save for one exception, all the route ciphers used by the USMTC conformed to this basic pattern. The things that changed from one cipher book to the next were the indicators for the dimensions of the matrices and for the routes, and the "arbitraries" or code equivalents for the various items comprising the "vocabulary," the number of them increasing from one edition to the next, just as might be expected. The sole exception to this basic pattern is to be seen in Cipher Book No. 9 and on only one page of the book. I will show you that page. (See Fig. 60.)

What we have here is a deviation from the straightforward route transposition, "up the . . . column, down the . . . column," etc. By introducing one diagonal path in the route (the 6th, 7th, 8th, 9th, 10th words in a message of five columns, and the 1st, 2nd, 3rd, 4th, 5th, and 6th words in a message of six columns) the simple up and down route no longer holds true. The words on the diagonal interrupt the normal up and down paths and introduce complexities in the method. In fact, the complexities seemed to be a bit too much for the USMTC cipher operators because, as far as available records show, these complicated routes were never used.

I now wish to make a number of general and a few specific comments on Plum's description of the cryptosystems used by the USMTC.

First, we have learned that although Anson Stager has been credited with inventing the type of cipher under consideration in this study, he was anticipated in the invention by about 200 years. Also, he is given the lion's share of the credit for devising those ciphers although he did have a number of collaborators. Plum names four of them, presumably because he thought them worthy of being singled out for particular attention. Plum and others tell us that copies of messages handled by the USMTC were sometimes intercepted by the enemy but not solved. He cites no authority for this last statement, merely saying that such intercepts were published in the newspapers of the Confederacy with the hope that somebody would come up with their solution. And it may be noted that none of the Confederate accounts of war activities cite instances of the solution of intercepted USMTC messages, although there are plenty of citations of instances of interception and solution of enciphered visual transmissions of the Federal Army's Signal Corps.

[4] It was the usual practice to use for address and signature the names of the USMTC operators concerned.

Message or Division of ...6... Lines.

COMMENCEMENT WORDS.

Yates, Lincoln, Chase	5 COLUMNS	Stanton, McClellan, McDowell	6 COLUMNS	Halleck, Buell, Sibley	7 COLUMNS

Seven. ROUTE.—Up the ...4... column; down the...3...; up the...5...; down the...2...; up the...1...; down the...6...; up the...7...

Five columns.

15	25	26	16	6
14	24	27	7	5
13	23	8	17	4
12	9	28	18	3
10	22	29	19	2
11	21	30	20	1

Six columns.

6	17	27	36	26	16
7	5	28	35	25	15
8	18	4	34	24	14
9	19	29	3	23	13
10	20	30	33	2	12
11	21	31	32	22	1

Figure 60.

Plum states that 12 different cipher books were employed by the Telegraph Corps, but I think there were actually only eleven. The first one was not numbered, and this is good evidence that a long war was not expected. This first cipher book had 16 printed pages. But for some reason, now impossible to fathom, the sequence of numbered books thereafter was as follows: Nos. 6 and 7, which were much like the first (unnumbered) one; then came Nos. 12, 9, 10—in that strange order; then came Nos. 1 and 2; finally came Nos. 3, 4, and 5. (Apparently there was no No. 8, or No. 11—at least they are never mentioned.) It would be ridiculous to think that the irregularity in numbering the successive books was for the purpose of communication security, but there are other things about the books and the cryptosystem that appear equally silly. There may have been good reasons for the erratic numbering of the books, but if so, what they were is now unknown. Plum states that No. 4, the last one used in the war, was placed into effect on 25 March 1865, and that it and all other ciphers were discarded on 20 June 1865. However, as noted, there was a No. 5, which Plum says was given a limited distribution. I have a copy of it, but whether it was actually put into use I do not know. Like No. 4, it had 40 pages. About 20 copies were sent to certain members of the USMTC, scattered among 12 states; and, of course, Washington must have had at least one copy.

We may assume with a fair amount of certainty that the first (the unnumbered) cipher book used by the USMTC was merely an elaboration of the one Stager produced for the communi-

cations of the governors of Ohio, Indiana and Illinois, and of which a copy is given by only one of the writers who have told us about these ciphers, namely, David H. Bates. Bates, in his series of articles entitled "Lincoln in the Telegraph Office" (*The Century Magazine*, Vol. LXXIV, Nos. 1–5, May-Sept, 1907)[4] shows a facsimile thereof (p. 292, June 1907 issue), and I have had as good a reproduction made of it as is possible from the rather poor photographic facsimile. The foregoing cipher is the prototype upon which all subsequent cipher books were based, the first of the War Department series being the one shown by Plum.

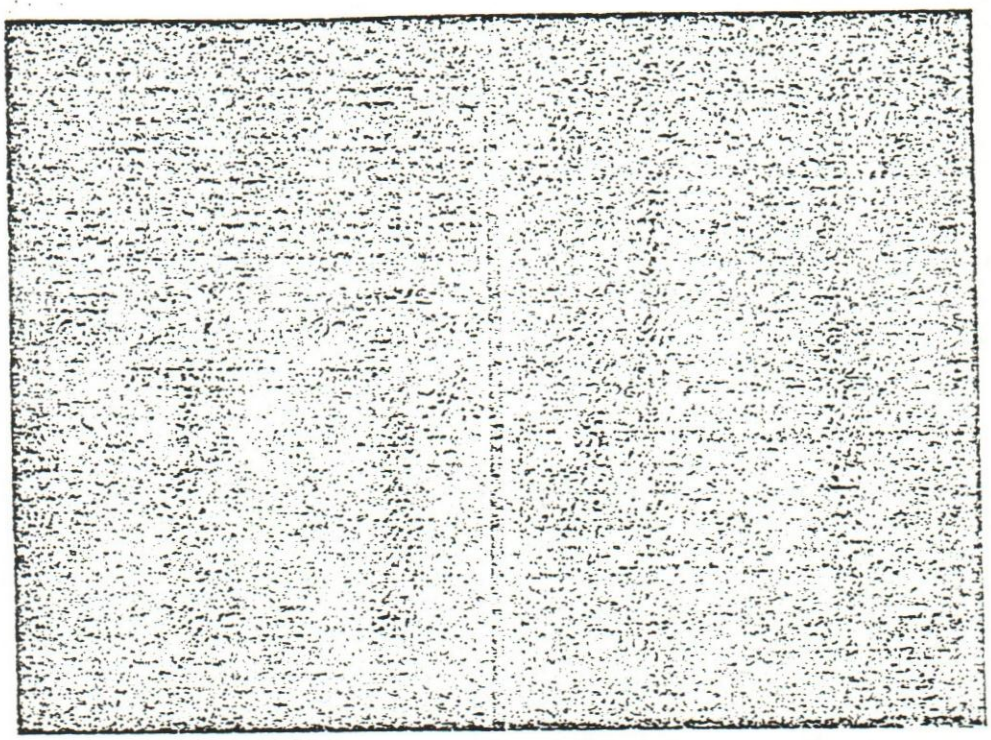


Figure 61.

When these ciphers came into use it was not the practice to misspell certain words intentionally; but as the members of the USMTC (who, as I've told you, not only served as telegraph operators but also as cipher clerks) developed expertness, the practice of using nonstandard orthography was frequently employed to make solution of messages more difficult. You have already seen examples of this practice, and one can find hundreds of other examples of this sort of artifice. Then, further to increase security, more and more code equivalents were added to represent such things as ordinal and cardinal numbers, months of the year, days of the week, hours of the day, punctuation, etc. As a last step, additional code equivalents for frequently used words and phrases were introduced. One good example of two typical pages from one of these books will characterize them all.

You will notice that the code equivalents are printed but their meanings are written in by hand. This was usually the case, and the reason is obvious: for economy in printing costs, because the printed code equivalents of plaintext items in cipher books belonging to the same series are identical; only their meanings change from one book to another, and of course, the transposition routes, their indicators, and other variables change from one book to another. I

[4] The series was then put out in book form under the same title by the Appleton-Century Company, New York, 1907, reprinted in 1939.

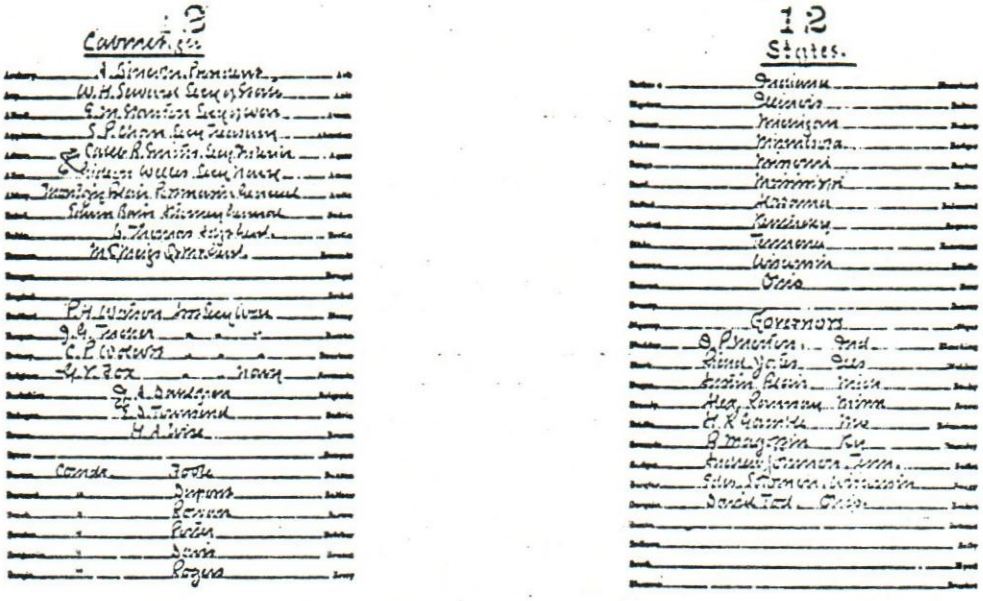


Figure 62.

am fortunate in having six of these cipher books in my private collection, so that comparisons among them are readily made. The first feature to be noted is that the code equivalents are all good English dictionary words (or proper nouns), of not less than three nor more than seven (rarely eight) letters. A careful scrutiny shows that in the early editions the code equivalents are such as are not very likely to appear as words in the plaintext messages; but in the later editions, beginning with No. 12, *more than 50% of the words used as code equivalents are such as might well appear in the plain text of messages.* For example, words such as AID, ALL, ARMY, ARTILLERY, JUNCTION, CONFEDERATE, etc., baptismal names of persons, and names of cities, rivers, bays, etc., appear as code equivalents. Among names used as code equivalents are SHERMAN, LINCOLN, THOMAS, STANTON, and those of many other prominent officers and officials of the Union Army and the Federal Government, as well as of the Confederate Army and Government; and, even more intriguing, such names were employed as indicators for the number of columns and the routes used—the so-called "Commencement Words." It would seem that names and words such as those I've mentioned might occasionally have brought about instances where difficulty in deciphering messages arose from this source of confusion, but the literature doesn't mention them. I think you already realize why such commonly used proper names and words were not excluded. There was, indeed, method in this madness.

But what is indeed astonishing to note is that in the later editions of these cipher books, in a great majority of cases, the words used as "arbitraries" differ from one another by at least two letters (for example, LADY, and LAMB, LARK and LAWN, ALBA and ASIA, [illegible] and WICK, MILK and MINT), or by more than two (for example MYRTLE and MYSTIC, CARBON and CANCER, ANDES and ATLAS). One has to search for cases in which two words differ by only one letter, but they can be found if you search long enough for them, as, for example, QUINCY and QUINCE, PINE and PIKE, NOSE and ROSE. Often there are words with the same initial trigraph or tetragraph, but then the rest of the letters are such that errors in transmission or reception would easily manifest themselves, as, for example, in the cases of MONSTER and MONARCH, MAGNET and MAGNOLIA. All in all, it is important to note that the compiler or compilers of these cipher books had adopted a principle known today as the "two-letter differential," a feature found only in codebooks of a much later date. In brief, the principle involves the use, in a given codebook, of code groups differing

from one another by at least two letters. This principle is employed by knowledgeable code compilers to this very day, not only because it enables the recipient of a message to detect errors in transmission or reception, but also to correct them. This is made possible if the permutation tables used in constructing the code words are printed in the codebooks, so that most errors can be corrected without calling for a repetition of the transmission. It is clear, therefore, that the compilers of these cipher books took into consideration the fact that errors are to be expected in Morse telegraphy, and by incorporating, but only to a limited extent, the principle of the two-letter differential, they tried to guard against the possibility that errors might go undetected. Had artificial 5-letter groups been used as code equivalents, instead of dictionary words, possibly the cipher books would also have contained the permutation tables. But it must be noted that permutation tables made their first appearance only about a quarter of a century after the Civil War had ended, and then only in the most advanced types of commercial codes.

There is, however, another feature about the words the compilers of these books chose as code equivalents. It is a feature that manifests real perspicacity on their part, and you probably already have divined it. A few moments ago I said that I would explain why, in the later and improved editions of these books, words which might well be words in plaintext messages were not excluded from the lists of code equivalents: it involves the fact that the basic nature of the cryptosystem in which these code equivalents were to be used was clearly recognized by those who compiled the books. Since the cryptosystem was based upon *word* transposition, what could be more confusing to a would-be cryptanalyst, working with messages in such a system, than to find himself unable to decide whether a word in the cipher text of a message he is trying to solve is actually in the original plaintext message and has its normal meaning, or is a code word with a secret significance—or even a null, a nonsignificant word, a "blind" or a "check word," as those elements were called in those days? That, no doubt, is why there are, in these books, so many code equivalents which might well be "good" words in the plaintext messages. And in this connection I have already noted an additional interesting feature: at the top of each page devoted to indicators for signaling the number of columns or rows in the specific matrix for a message are printed the so-called "commencement words," or what we now call "indicators." Now there are nine such words, in sets of three, any one of which *could* actually be a real word or name in the plaintext message. Such words when used as indicators could be very confusing to enemy cryptanalysts, especially after the transposition operation. Here, for example, are the "commencement words" on page 5 of cipher book No. 9: Army, Anson, Action, Astor, Advance, Artillery, Anderson, Ambush, Agree; on page 7 of No. 10: Cairo, Curtin, Cavalry, Congress, Childs, Calhoun, Church, Cobb, etc. Moreover, in Nos. 1, 3, 4, 5, and 10 the "line indicators," that is, the words indicating the number of horizontal rows in the matrix, are also words such as could easily be words in the plaintext messages. For example, in No. 1, page 3, the line indicators are as follows:

Address	1	Faith	Assume	6	Bend
Adjust	2	Favor	Awake	7	Avail
Answer	3	Confine	Encamp	8	Active
Appear	4	Bed	Enroll	9	Absent
Appeal	5	Beef	Enough	10	Accept

Note two things in the foregoing list: first, there are variants—there are two indicators for each case; and second, the indicators are not in strict alphabetic sequence. This departure from strict alphabeticity is even more obvious in the pages devoted to vocabulary, a fact of much importance cryptanalytically. Note this feature, for example, in Fig. 62, which shows pages 14 and 15 of cipher book No. 12.

In this respect, therefore, these books partake somewhat of the nature of two-part or "randomized" codes, or, in British terminology, "hatted" codes. In the second lecture of this series the physical difference between one-part and two-part codes was briefly explained, but

an indication of the technical cryptanalytic difference between these two types of codes may useful at this point. Two-part codes are much more difficult to solve than one-part codes, which both the plaintext elements and their code equivalents progress in parallel sequences. In the latter type, determination of the meaning of one code group quickly and rather easily leads to the determination of the meanings of other code groups above or below the one that has been solved. For example, in the following short but illustrative example, if the meaning of code group 1729 has been determined to be "then," the meaning of the code group 1728 could well be "the" and that of

1728 — the	7621 — the
1729 — then	0972 — then
1730 — there	1548 — there

the code group 1730, "there." But in a two-part code, determining the meaning of the code group 0972 to be "then" gives no clue whatever as to the meaning of the groups 7621 or 1548. For use in decoding messages in such a code there must be a section in which the code groups are listed in numerical sequence and are accompanied by their meanings, which, of course, will be in a random sequence. The compilers of the USMTC cipher books must have had a very clear idea of what I have just explained, but they made a compromise of a practical nature between a strictly one-part and a strictly two-part code, because they realized that a code of the latter sort is twice as bulky as one of the former sort, besides being much more laborious to compile and check the contents for accuracy. The arrangement they chose wasn't too bad, so far as cryptosecurity was concerned. As a matter of fact, and speaking from personal experience in decoding a rather long message addressed to General Grant, I had a difficult time in locating many of the code words in the book, because of the departure from strict alphabeticity. I came across that message in a workbook in my collection, the workbook of one of important members of the USMTC—none other than our friend Plum, from whose book, *The Military Telegraph during the Civil War*, comes much of the data I've presented in this lecture. On the flyleaf of Plum's workbook there appears, presumably in his own handwriting, the legend "W. R. Plum Chf Opr with Gen. G. H. Thomas." Here's one of the messages he enciphered in cipher book No. 1, the book in which, he says, more important telegrams were sent than in any other:

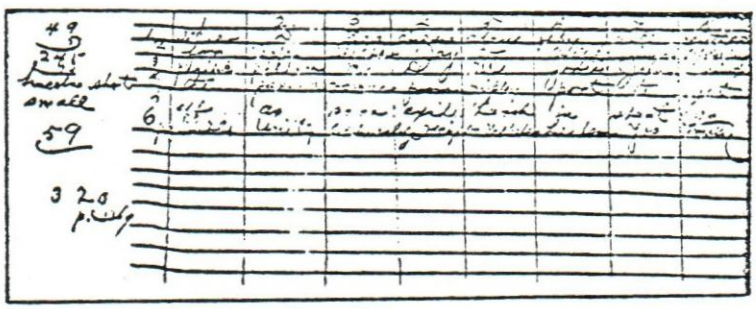


Figure 63.

e how many "arbitraries" appear in the plaintext message, that is *before* transposition. ...er transposition, the melange of plain text, code words, indicators and nulls makes the cryp-

CONFEDERATE STATES CIPHER KEY.

	26	25	24	23	22	21	20	19	18	17	16	15	14	13	12	11	10	9	8	7	6	5	4	3	2	1
1	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
2	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	a
3	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b
4	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c
5	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d
6	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e
7	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f
8	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g
9	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h
10	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i
11	k	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j
12	l	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k
13	m	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l
14	n	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m
15	o	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n
16	p	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o
17	q	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p
18	r	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q
19	s	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r
20	t	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s
21	u	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t
22	v	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u
23	w	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v
24	x	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w
25	y	z	a	b	c	d	e	f	g	h	i	j	k	l	m	n	o	p	q	r	s	t	u	v	w	x
26	z	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

Figure 64.

togram mystifying.[6] And yet, was the system as inscrutable as its users apparently thought? It is to be remembered, of course, that messages were then transmitted by wire telegraphy, not by radio, so that enemy messages could be obtained only by "tapping" telegraph lines or capturing couriers or headquarters with their files intact. Opportunities for these methods of acquiring enemy traffic were not frequent, but they did occur from time to time, and in one case a Confederate signalman hid in a swamp for several weeks and tapped a Federal telegraph line, obtaining a good many messages. What success, if any, did Confederate cryptanalysts have in their attempts to solve such USMTC cryptograms as they did intercept? We shall try to answer this question in due time.

As indicated earlier, there were no competing signal organizations in the Confederacy as there were on the Union side. There was nothing at the center of government in Richmond or in the combat zone comparable to the extensive and tightly controlled civilian military telegraph organization which Secretary Stanton ruled with such an iron hand from Washington. Almost as a concomitant, it would seem, there was in the Confederacy, save for two exceptional cases, one and only one officially established cryptosystem to serve the need for protecting tactical as well as strategic communications, and that was the so-called Vigenère Cipher, which apparently was the cipher authorized in an official manual prepared by Captain J. H. Alexander as the partial equivalent of Myer's *Manual of Signals*. You won't find the name Vigenère in

[6] In searching for a good example my eye caught the words "Lincoln shot" at the left of the matrix and I immediately thought that the message had to do with Booth's assassination of the President. But after hurriedly translating the message and finding nothing in it having anything to do with the shooting it occurred to me to look up the indicators for a matrix of six rows and eight columns. They turned out to be LINCOLN (message of 8 columns), SHOT (6 rows). The word SMALL beneath the "Lincoln shot" is a variant for SHOT, also meaning "6 rows."

any of the writings of contemporary signal officers of either the North or the South. The nalmen of those days called it the "Court Cipher," this term referring to the system in ommon use for diplomatic or "court" secret communications about this period in history. It is that cipher which employs the so-called Vigenère Square with a repeating key.[1] Here in Fig. 64 is the square which Plum calls the "Confederate States Cipher Key" and which is followed by his description of its manner of employment.

There are certain comments to be made on the two sample messages given by Plum. In the first place, in one of the messages certain words are left unenciphered; in the second place, in both sample messages, the ciphers retain and clearly show the lengths of the words which have been enciphered. Both of these faulty practices greatly weaken the security of ciphers because they leave good clues to their contents and can easily result in facilitating solution of the messages. We know today that cipher messages must leave nothing in the clear. Even the address and the signature, the date, time and place of origin, etc., should if possible be hidden; and the cipher text should be in completely regular groupings, first, so as not to disclose the lengths of the plaintext words, and second, to promote accuracy in transmission and reception.

So far as my studies have gone, I have not found a single example of a Confederate Vigenère cipher which shows neither of these two fatal weaknesses. The second of the two examples is the only case I have found in which there are no unenciphered words in the text of the message. And the only example I have been able to find in which word lengths are not shown (save for one word) is in the case of the following message:

Vicksburg, Dec. 26, 1862.

GEN. J. E. JOHNSTON, JACKSON:

I prefur oaavvr, it has reference to xhvkjqchffabpzelreqpzwnyk to prevent anuzeyxswstpjw at that point, raeelpsghvelvtzfautlilasit lhifnaigtsmmlfgccajd.

(Signed) J. C. PEMBERTON
Lt. Gen. Comdg.

Even in this case there are unenciphered words which afforded a clue which enabled our man Plum to find the key and solve the message. It took some time, however, and the story is worth telling.

According to Plum, the foregoing cipher message was the very first one captured by USMTC operators, and it was obtained during the siege of Vicksburg, which surrendered on 4 July 1863. But note the date of the message: 26 December 1862. What was done with the captured message during the months from the end of December 1862 to July 1863? Apparently nothing. Here is what Plum reports:

> "What efforts General Grant caused to be made to unravel this message, we know not. It was not until October, 1864, that it and others came into the hands of the telegraph cipherers, at New Orleans, for translation . . . .
>
> The New Orleans operators who worked out this key (Manchester Bluff) were aided by the Pemberton cipher and the original telegram, which was found among that general's papers, after the surrender of Vicksburg; also by the following cipher dispatch, and one other."

Plum gives the messages involved, their solution, and the keys, the latter being the three cited above. It would seem that if the captured Pemberton message had been brought to General Grant's attention and he did nothing about it, he was not much interested in intelligence. Secondly, the solution of the Pemberton message and the others apparently took some time, even though there was one message with its plain text (the Pemberton message) and two messages not only with interspersed plaintext words but also with spaces showing word lengths. But Plum does not indicate how long it took for solution. Note that he merely says that the messages came into the hands of the telegraph cipherers in October 1864; he does not tell when solution was reached.

---

[1] A key word is employed to change the alphabets cyclically, thus making the cipher what is called today a . iodic polyalphabetic cipher controlled by the individual letters of a key, which may consist of a word, a phrase, or even of a sentence, repeated as many times as necessary.

In the various accounts of these Confederate ciphers there is one and only one writer who makes a detailed comment on the two fatal practices to which I refer. A certain Dr. Charles E. Taylor, a Confederate veteran (in an article entitled "The Signal and Secret Service of the Confederate States," published in the Confederate Veteran, Vol. XL, Aug-Sept 1932), after giving an example of encipherment according to the "court cipher," says:

> "It hardly needs to be said that the division between the words of the original message as given above was not retained in the cipher. Either the letters were run together continuously or breaks, as if for words, were made at random. Until the folly of the method was revealed by experience, only a few special words in a message were put into cipher, while the rest was sent in plain language. Thus . . . I think it may be said that it was impossible for well prepared cipher to be correctly read by any one who did not know the key-word. Sometimes, in fact, we could not decipher our own messages when they came over telegraph wires. As the operators had no meaning to guide them, letters easily became changed and portions, at least, of messages rendered unmeaningly (sic) thereby."

Frankly, I don't believe Dr. Taylor's comments are to be taken as characterizing the practices that were usually followed. No other ex-signalman who has written about the ciphers used by the Confederate Signal Corps makes such observations, and I think we must simply discount what Dr. Taylor says in this regard.

It would certainly be an unwarranted exaggeration to say that the two weaknesses in the Confederate cryptosystem cost the Confederacy the victory for which it fought so mightily, but I do feel warranted at this moment in saying that further research may well show that certain battles and campaigns were lost because of insecure cryptocommunications.

A few moments ago I said that, save for an exception or two, there was in the Confederacy one and only one cryptosystem to serve the need for secure tactical as well as strategic communications. One of these exceptions concerned the cipher used by General Beauregard after the battle of Shiloh (8 April 1862). This cipher was purely monoalphabetic in nature and was discarded as soon as the official cipher system was prescribed in Alexander's manual. It is interesting to note that this was done after the deciphered message came to the attention of Confederate authorities in Richmond via a northern newspaper. It is also interesting to note that the Federal War Department had begun using the route cipher as the official system for USMTC messages very promptly after the outbreak of war, whereas not until 1862 did the Confederate States War Department prepare an official cryptosystem, and then it adopted the "court cipher."

The other exception involved a system used at least once before the official system was adopted, and it was so different from the latter that it should be mentioned. On 26 March 1862, the Confederate States President, Jefferson Davis, sent General Johnston by special messenger a dictionary, with the following accompanying instruction:[3]

> "I send you a dictionary of which I have the duplicate, so that you may communicate with me by cipher, telegraphic or written, as follows: First give the page by its number; second, the column by the letter L, M or R, as it may be, in the left-hand, middle, or right-hand columns; third, the number of the word in the column, counting from the top. Thus, the word junction would be designated by 146, L, 20."

The foregoing, as you no doubt have already realized, is one of the types of cryptosystems used by both sides during the American Revolutionary Period almost a century before, except that in this case the dictionary had three columns to the page instead of two. I haven't tried to find the dictionary but it shouldn't take long to locate it, since the code equivalent of the word "junction" was given: 146, L, 20. Moreover, there is extant at least one full long message, with its decode. How many other messages in this system there may be in the National Archives I don't know.

Coming back now to the "court cipher," you will probably find it just as hard to believe, as I find it, that according to all accounts three and only three keys were used by the Confederates

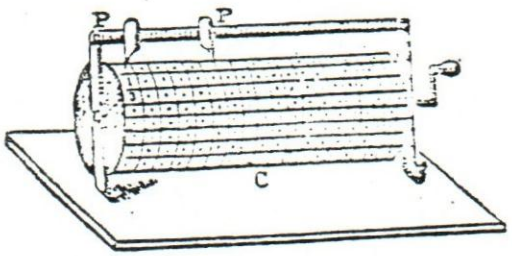
[3] *Battles and Leaders of the Civil War.* The Century Co., New York, 1884, Vol. I, p. 581.

ng the three and a half years of warfare from 1862 to mid-1865. It is true that Southern almen make mention of frequent changes in key but only the following three are specifically cited:

1) COMPLETE VICTORY
2) MANCHESTER BLUFF
3) COME RETRIBUTION.

It seems that all were used concurrently. There may have been a fourth key, IN GOD WE TRUST, but I have seen it only once, and that is in a book explaining the "court cipher." Note that each of the three keys listed above consists of exactly 15 letters; but why this length was chosen is not clear. Had the rule been to make the cipher messages contain only 5-letter groups, the explanation would be easy: 15 is a multiple of 5 and this would be of practical value in checking the cryptographic work. But, as has been clearly stated, disguising word lengths was apparently not the practice even if it was prescribed, so that there was no advantage in choosing keys which contain a multiple of 5 letters. And, by the way, doesn't the key COME RETRIBUTION sound rather ominous to you even these days?

Sooner or later a Confederate signal officer was bound to come up with a device to simplify enciphering operations, and a gadget devised by a Captain William N. Barker seemed to meet the need. In Myer's *Manual* there is a picture of one form of the device, shown here in Fig. 65. I don't think it necessary to explain how it worked, for it is almost self-evident. Several of these devices were captured during the war, one of them being among the items in the NSA Museum (Fig. 66). This device was captured at Mobile in 1865. All it did was to mechanize, in a rather inefficient manner, the use of the Vigenère Cipher.



Cipher Reel.

Figure 65.

How many of these devices were in existence or use is unknown, for their construction was an individual matter—apparently it was not an item of regular issue to members of the corps.

In practically every account of the codes and ciphers of the Civil War you will find references to ciphers used by Confederate secret service agents engaged in espionage in the North as well as in Canada. In particular, much attention is given to a set of letters in cipher, which were intercepted by the New York City Postmaster and which were involved in a plot to print Confederate currency and bonds. Much ado was made about the solution of these ciphers by cipher operators of the USMTC in Washington and the consequent breaking up of the plot. But I won't go into these ciphers for two reasons. First, the alphabets were all of the simple monoalphabetic type, a total of six altogether being used. Since they were composed of a different series of symbols for each alphabet, it was possible to compose a cipher word by jumping from one series to another without any external indication of the shift. However, good eyesight and a bit of patience were all that was required for solution in this case because of the inept manner in which the system was used: whole words, sometimes several successive words, were

enciphered by the same alphabet. But the second reason for my not going into the story is that my friend and colleague of my NSA days, Edwin C. Fishel, has done some research among the records in our National Archives dealing with this case, and he has found something which is of great interest and which I feel bound to leave for him to tell at some future time, as that is his story, not mine.

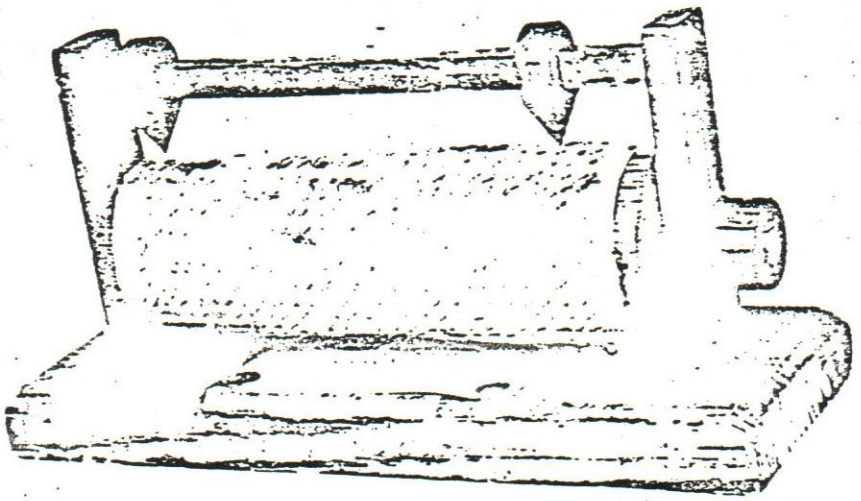


Figure 66.

So very fragmentary was the amount of cryptologic information known to the general public in these days that when there was found on John Wilkes Booth's body a cipher square which was almost identical with the cipher square which had been mounted on the cipher reel found in Confederate Secretary of State Judah P. Benjamin's office in Richmond, the Federal authorities in Washington attempted to prove that this necessarily meant that the Confederate leaders were implicated in the plot to assassinate Lincoln and had been giving Booth instructions in cipher. Fig. 67 is a picture of the cipher square found on Booth, and also in a trunk in his hotel room in Washington.

The following is quoted from Philip Van Doren Stern's book entitled *Secret Missions of the Civil War* (Rand McNally and Co., New York, 1951, p. 320):

> "Everyone in the War Department who was familiar with cryptography knew that the Vigenère was the customary Confederate cipher and that for a Confederate agent (which Booth is known to have been) to possess a copy of a variation of it meant no more than if a telegraph operator was captured with a copy of the Morse Code. Hundreds—and perhaps thousands—of people were using the Vigenère. But the Government was desperately seeking evidence against the Confederate leaders so they took advantage of the atmosphere of mystery which has always surrounded cryptography and used it to confuse the public and the press. This shabby trick gained nothing, for the leaders of the Confederacy eventually had to be let go for lack of evidence."

To the foregoing I will comment that I doubt very much whether "everyone in the War Department who was familiar with cryptography knew that the Vigenère was the customary Confederate cipher." Probably not one of them had even heard the name Vigenère or had even seen a copy of the table, except those captured in operations. I doubt whether anyone on either side even knew that the cipher used by the Confederacy had a name; or least of all, that a German Army reservist named Kasiski, in a book published in 1863, showed how the Vigenère cipher could be solved by a straightforward mathematical method.

I have devoted a good deal more attention to the methods and means for cryptocommunications in the Civil War than they deserve, because professional cryptologists of 1961 can hardly be impressed either by their efficacy from the point of view of ease and rapidity in the

ographic processing, or by the degree of the technical security they imparted to the messages they were intended to protect. Not much can be said for the security of the visual signaling systems used in the combat zone by the Federal Signal Corps for tactical purposes, because they were practically all based upon simple monoalphabetic ciphers, or variations thereof, as, for instance, when whole words were enciphered by the same alphabet. There is plenty of evidence that Confederate signalmen were more or less regularly reading and solving those signals. What can be said about the security of the route ciphers used by the USMTC for strategic or high command communications in the zone of the interior? It has already been indicated that, according to accounts by ex-USMTC men, such ciphers were beyond the cryptanalytic capabilities of Confederate cryptanalysts, but can we really believe that this

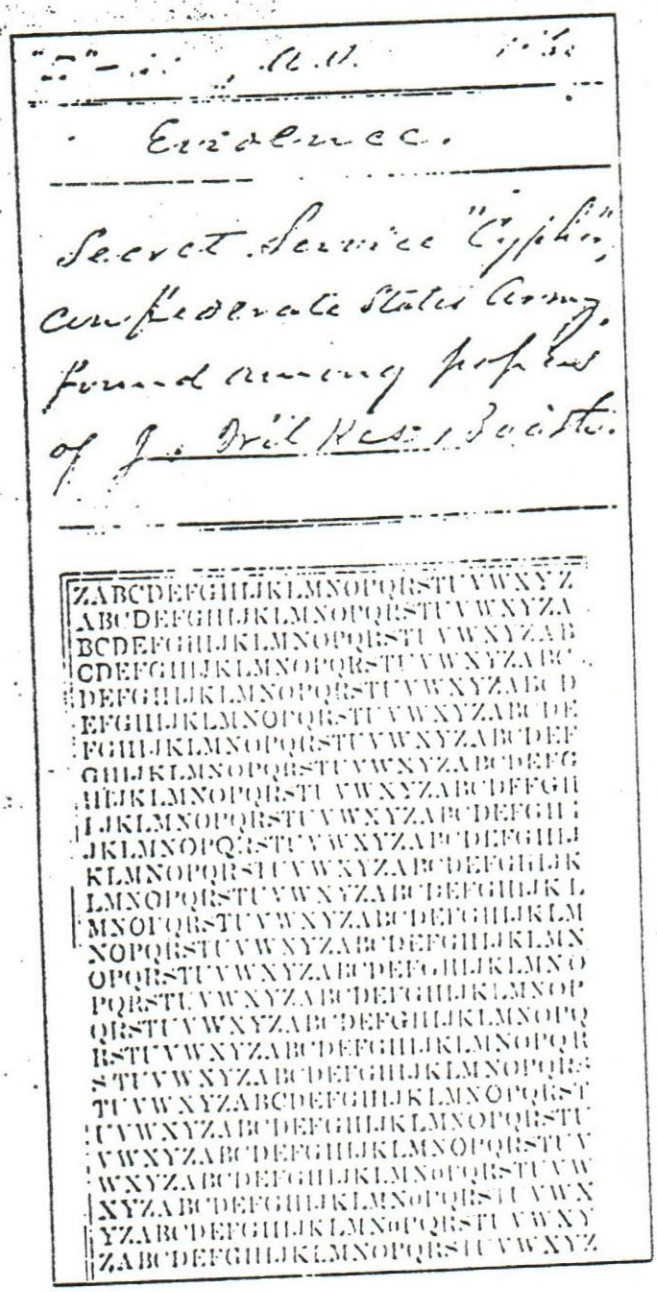


Figure 67.

was true? Considering the simplicity of these route ciphers and the undoubted intellectual capacities of Confederate officers and soldiers, why should messages in these systems have resisted cryptanalytic attack? In many cases the general subject matter of a message and perhaps a number of specific items of information could be detected by quick inspection of the message. Certainly, if it were not for the so-called "arbitraries," the general sense of the message could be found by a few minutes work, since the basic system must have been known through the capture of cipher books, a fact mentioned several times in the literature. Capture of but one book (they were all generally alike) would have told Confederate signalmen exactly how the system worked, and this would naturally give away the basic secret of the superseding book. So we must see that whatever degree of protection these route ciphers afforded, message security depended almost entirely upon the number of "arbitraries" actually used in practice. A review of such messages as are available shows wide divergencies in the use of "arbitraries." In any event, the number actually present in these books must have fallen far short of the number needed to give the real protection that a well-constructed code can give. Thus it seems to me that the application of native intelligence, with some patience, should have been sufficient to solve USMTC messages—or so it would be quite logical to assume. That such an assumption is well warranted is readily demonstrable.

It was, curiously enough, at about this point in preparing this lecture that , whom I have mentioned before, gave me just the right material for such a demonstration. In June of 1960, had given who is also a member of NSA and who knew nothing about the route ciphers of the USMTC, the following authentic message sent on 1 July 1863 by General George G. Meade, at Harrisburg, Pennsylvania, to General Couch at Washington. (See Fig. 68.)

It took Mr. Bridges only a few hours, five or six, to solve the cryptogram, and he handed the following plain text to Mr. Fishel:

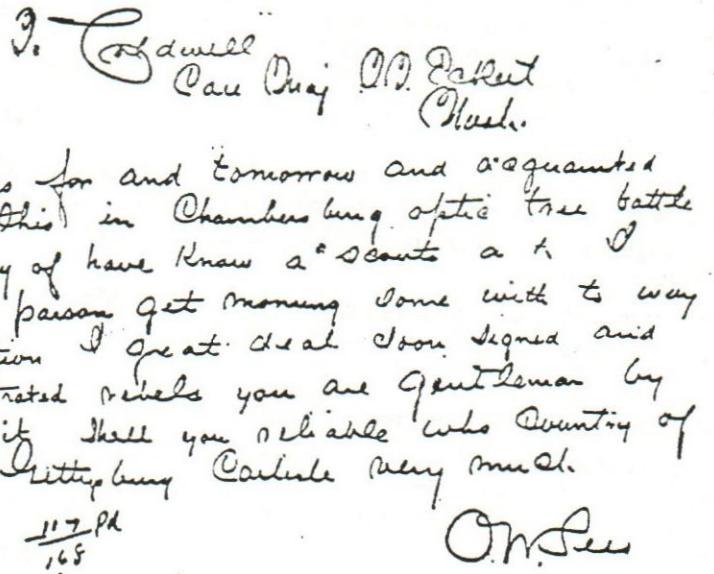


Figure 68.

Thomas been it—(Nulls)
For Parson. I shall try and get to you by tomorrow morning a reliable gentleman and some scouts who are acquainted with a country you wish to know of. Rebels this way have all concentrated in direction of Gettysburg and Chambersburg. I occupy Carlisle. Signed Optic. Great battle very soon. tree much deal—(Nulls)

ıe foregoing solution is correct, save for one pardonable error: "Thomas" is not a "null" n indicator for the dimensions of the matrix and the route. "Parson" and "Optic" are code names, and I imagine that Mr. Bridges recognized them as such but, of course, he had no way of interpreting them, except perhaps by making a careful study of the events and commanders involved in the impending action, a study he wasn't called upon to undertake.

The foregoing message was enciphered by Cipher Book No. 12, in which the indicator THOMAS specifies a "Message of 10 lines and 5 columns." The route was quite simple and straightforward: "Down the 1st (column), up the 3rd; down the 2nd; up the 5th down the 4th."

It is obvious that in this example the absence of many "arbitraries" made solution a relatively easy matter. What Mr. Bridges would have been able to do with the cryptogram had there been many of them is problematical. Judging by his worksheets, it seemed to me that Mr. Bridges did not realize when he was solving the message that a transposition matrix was involved; and on questioning him on this point his answer was in the negative. He realized this only later.

A minor drama in the fortunes of Major General D. C. Buell, one of the high commanders of the Federal Army, is quietly and tersely outlined in two cipher telegrams. The first one, sent on 29 September 1862, from Louisville, Kentucky, was in one of the USMTC cipher books and was externally addressed to Colonel Anson Stager, head of the USMTC, but the internal addressee was Major General H. W. Halleck, "General-in-Chief" [our present day "Chief of Staff"]. The message was externally signed by William H. Drake, Buell's cipher operator, but the name of the actual sender, Buell, was indicated internally. Here's the telegram:

COLONEL ANSON STAGER, Washington:

Austria await I in over to requiring orders olden rapture blissful for your instant command turned and instructions and rough looking further shall further the Camden me of ocean September poker twenty I the to I command obedience repair orders quickly pretty Indianapolis your him accordingly my fourth received 1862 wounded nine have twenty turn have to to to alvord hasty.

WILLIAM H. DRAKE

Rather than give you the plain text of this message, perhaps you would like to work it out for yourselves, for with the information you've already received the solution should not be difficult. The message contains one error, which was made in its original preparation: one word was omitted.

The second telegram, only one day later, was also from Major General Buell, to Major General Halleck, but it was in another cipher book—apparently the two books involved were used concurrently. Here it is:

GEORGE C. MAYNARD, Washington:

Regulars ordered of my to public out suspending received 1862 spoiled thirty I dispatch command of continue of best otherwise worst Arabia my command discharge duty of my last for Lincoln September period your from sense shall duties the until Seward ability to the I a removal evening Adam herald tribune.[1]

PHILIP BRUNER

As before, I will give you the opportunity to solve this message for yourselves. (At the end of the next lecture I shall present the plain text of both messages.)

Figure 69 is a photograph of an important message which you may wish to solve yourself. It was sent by President Jefferson Davis to General Johnston, on a very significant date, 11

[1] A curious coincidence—or was it a fortuitous foreshadowing of an event far in the future?—can be seen in the ence of the last two words of the cipher text. The message is dated September 30, 1862; the New York ...rald and the New York Tribune combined to make the New York Herald-Tribune on March 19, 1924—62 years later!

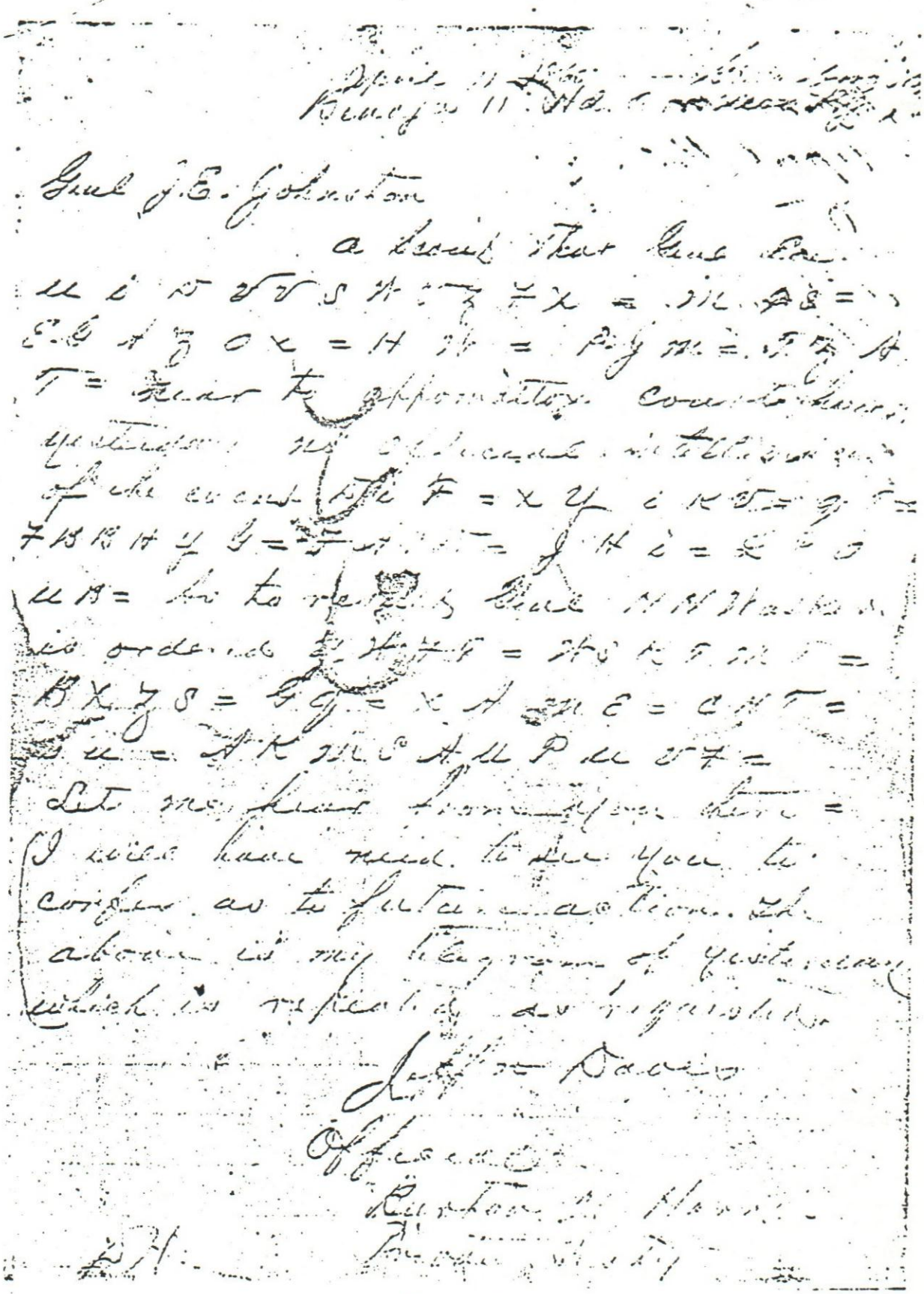


Figure 69.

ril 1865.* For ease in working on it I give also a transcription below, since the photograph ery old and in a poor state. I believe that this message does not appear in any of the ac-nts I've read.

Greensboro N.C.

April 11 1865
Benaja 11 Hd Q near R. G.

Genl J. E. Johnston

A scout (reports?) that Genl Lee
u i D v v s w v z F x – m q s – E G A z o x –
H W – P J M – T z A T – near to appomattox Court
house yesterday No official intelligence of the
event D i F – x y i k v – q T – F B B H Y G –
F A S D – J H i – L P O u B – As to result Gen H. H.
Walker is ordered Y W F T – W S K T M T – B X z S –
G q – X A m E – C H T – i u – A K M S A u P u V F –
Let me hear from you there– I will have need to
see you to confer as to future action. The above
is my telegram of yesterday which is repeated as
requested.

Jeffn Davis
Official
Burton Harrison
Private Secy

is time now to tell you what I can about the success or lack of success which each side with the cryptograms of the other side. I wish there were more information on this interesting subject than what I am about to present. Most of what sound information there is comes from a book by a man named J. Willard Brown, who served four full years in the Federal Army's Signal Corps. The book is entitled *The Signal Corps, U.S.A., in the War of the Rebellion*, published in Boston in 1896 by the U.S. Veteran Signal Corps Association. In his book Brown deals with the cryptanalytic success of both sides. First, let's see what the Union signalmen could do with rebel ciphers. Here are some statements he makes (p. 214):

> "The first deciphering of a rebel signal code of which I find any record was that made by Capt. J. S. Hall and Capt. R. A. Taylor, reported Nov. 25, 1862. Four days later, Maj. Myer wrote to Capt. Cushing, Chief Signal Officer, Army of the Potomac, not to permit it to become public 'that we translate the signal messages of the rebel army.'
>
> April 9, 1863, Capt. Fisher, near Falmouth, reported that one of his officers had read a rebel message which proved that the rebels were in possession of our code. The next day he was informed that the rebel code taken (from) a rebel signal officer was identical with one taken previously at Yorktown.
>
> He received from Maj. Myer the following orders:
>
> 'Send over your lines, from time to time, messages which, if it is in the power of the enemy to decipher them, will lead them to believe that we cannot get any clew to their signals.'
>
> 'Send also occasionally messages untrue, in reference to imaginary military movements, as for instance—"The Sixth Corps is ordered to reinforce Keyes at Yorktown."' "

Undoubtedly, what we have here are references to the general cipher system used by the Confederates in their electric-telegraph communications, for note the expression "Send over your lines." This could hardly refer to visual communications. Here we also have very early instances, in telegraphic communications, of what we call cover and deception, i.e., employing certain ruses to try to hide the fact that enemy signals could be read, and to try to deceive him by sending spurious messages for him to read, hoping the fraud will not be detected.

* I should warn you that it contains several errors!

Brown's account of Union cryptanalytic successes continues (p. 215):

> "In October, 1863, Capt. Merrill's party deciphered a code, and in November of the same year Capt. Thickstun and Capt. Marston deciphered another in Virginia.
>
> Lieut. Howgate and Lieut. Flook, in March, 1864, deciphered a code in the Western Army, and at the same time Lieut. Benner found one at Alexandria, Virginia.
>
> Capt. Paul Babcock, Jr., then Chief Signal Officer, Department of the Cumberland, in a letter dated Chattanooga, Tennessee, April 26, 1864, transmitting a copy of the rebel signal code, says:
>
> > 'Capt. Cole and Lieut. Howgate, acting Signal Officers, occupy a station of communication and observation on White Oak Ridge at Ringgold, Ga. . . . On the 22nd inst. the rebels changed their code to the one enclosed, and on the same day the above-mentioned officers by untiring zeal and energy succeeded in translating the new code, and these officers have been ever since reading every message sent over the rebel lines. Many of these messages have furnished valuable information to the general commanding the department.' "

The following is also from Brown (p. 279):

> "About the first of June (1864), Sergt. Colvin was stationed at Fort Strong, on Morris Island, with the several codes heretofore used by the rebels, for the purpose of reading the enemy signals if possible. For nearly two weeks nothing could be made out of their signals, but by persevering he finally succeeded in learning their codes. Messages were read by him from Beach Inlet, Battery Bee, and Fort Johnson. Gen. J. G. Foster, who had assumed command of the Department of the South, May 26th, was so much pleased with Sergt. Colvin's work, that in a letter addressed to Gen. Halleck, he recommended 'that he be rewarded by promotion to Lieutenant in the Signal Corps, or by a brevet or medal of honor.' This recommendation was subsequently acted upon, but, through congressional and official wrangling over appointments in the Corps, he was not commissioned until May 13, 1865, his commission dating from Feb. 14, 1865."

(p. 281):

> "During the month, Sergt. Colvin added additional laurels to the fame he had earned as a successful interpreter of rebel signals. The enemy had adopted a new cipher for the transmission of important messages, and the labor of deciphering it devolved upon the sergeant. Continued watchfulness at last secured the desired result, and he was again able to translate the important dispatches of the enemy for the benefit of our commandants. The information thus gained was frequently of special value in our operations, and the peculiar ability exhibited by the sergeant led Gen. Foster once more to recommend his promotion."

(p. 286)

> "About the same time an expedition under Gen. Potter was organized to act in conjunction with the navy in the vicinity of Bull's Bay. Lieut. Fisher was with this command, and by maintaining communications between the land and naval forces facilitated greatly the combined action of the command. Meanwhile every means was employed to intercept rebel messages. Sergt. Colvin, assigned to this particular duty, read all the messages within sight, and when the evacuation of Charleston was determined upon by the enemy, the first notification of the fact came in this way before the retreat had actually commenced. As a reward for conspicuous services rendered in this capacity, Capt. Merrill recommended that the sergeant be allowed a medal, his zeal, energy and labors fully warranting the honor.
>
> After the occupation of Charleston, communications was established by signals with Fort Strong, on Morris Island, Fort Johnson and James Island, Mount Pleasant, and Steynmeyer's Mills. A line was also opened with the position occupied by the troops on the south side of the Ashley river."

With regard to Confederate reading of Union visual signals, Brown makes the following observations of considerable interest (p. 274):

> "The absolute necessity of using a cipher when signalling in the presence of the enemy was demonstrated during these autumn months by the ease with which the rebels read our messages. This led to the issuing of an order that all important messages should be sent in cipher. Among the multitude of messages intercepted by the enemy, the following were some of the most important. . ."

Brown thereupon cites 25 such messages but he gives no indication whatever as to the source on which he obtained these examples or how he knew they had been intercepted. They all appear to be tactical messages sent by visual signals.

In many of the cases cited by Brown it is difficult to tell whether wig-wag or electric telegraph messages were involved. But in one case (evacuation of Charleston), it is perfectly clear that visual messages were involved, when Brown says that Sgt. Colvin "read all the messages within sight."

Further with regard to rebel cryptanalytic success with Union messages, Brown has this to say (p. 213):

> "The reports of Lieut. Frank Markoe, Signal Officer at Charleston, show that during the siege thousands of messages were sent from one post to another, and from outposts to headquarters, most of which could have been sent in no other way, and many were of great importance to the Confederate authorities.
>
> Lieut. Markoe says that he read nearly every message we sent. He was forewarned of our attack on the 18th of July, 1863. He adds regretfully, however, that through carelessness of the staff officers at headquarters it leaked out that he was reading our messages. Our officers then began to use the cipher disk. In August he intercepted the following message: 'Send me a copy of rebel code immediately, if you have one in your possession.' He therefore changed his code. . . . A little later our officers used a cipher which Lieut. Markoe says he was utterly unable to unravel."

It is unfortunate that neither Lieutenant Markoe, the Confederate cryptanalyst, nor Brown, the Union signalman, tell us what sort of cipher this was that couldn't be unravelled. I assume that it was the Myer disk used properly, with a key phrase of some length and with successive letters, not whole words, being enciphered by successive letters of the key. But this is only an assumption and may be entirely erroneous.

In the foregoing citations of cryptanalytic successes it is significant to note that visual messages were intercepted and read by both sides; second, that Confederate telegraphic messages protected by the Vigenère cipher were read by Union personnel whenever such messages were intercepted; and third, that USMTC telegraph messages protected by the route cipher, apparently intercepted occasionally, were never solved. Later I shall make some comments on this last statement, but at the moment let us note that technically the Vigenère cipher is theoretically much stronger than the route cipher, so that we have here an interesting situation, *viz*, the users of a technically inferior cryptosystem were able to read enemy messages protected by a technically superior one, but the users of a technically superior cryptosystem were not able to read enemy messages protected by a technically inferior one—a curious situation indeed.

I can hardly close this lecture without citing a couple of messages which appear in nearly every account I've seen of the codes and ciphers of the Civil War. These are messages which were sent by President Lincoln under circumstances in which, allegedly, the usual cipher could not be or, at least was not, employed. The first of the two was sent on 25 November 1862 from the White House to Major General Burnside, Falmouth, Virginia. The circumstances are so bizarre that if I merely presented the cipher message to you without some background I doubt if you would believe me. And even after I've presented the background, I'm sure you won't know what to think. I, myself, don't really know whether to take the incident seriously or not. Let me quote from an account of it in the book by David Homer Bates, one of the last members of the USMTC, in his *Lincoln in the Telegraph Office* (Appleton-Century Co., New York, 1939, pp. 58-61):

> "During Burnside's Fredericksburg campaign at the end of 1862, the War Department operators discovered indications of an interloper on the wire leading to his headquarters at Aquia Creek. These indications consisted of an occasional irregular opening and closing of the circuit and once in a while strange signals, evidently not made by our own operators. It is proper to note that the characteristics of each Morse operator's sending are just as pronounced and as easily recognized as those of ordinary handwriting, so that when a message is transmitted over

a wire, the identity of the sender may readily be known to any other operator within hearing who has ever worked with him. A somewhat similar means of personal identification occurs every day in the use of the telephone.

"At the time referred to, therefore, we were certain that our wire had been tapped. In some way or other the Confederate operator learned that we were aware of his presence, and he then informed us that he was from Lee's army and had been on our wire for several days, and that, having learned all that he wanted to know, he was then about to cut out and run. We gossiped with him for a while and then ceased to hear his signals and believed that he had gone.

"We had taken measures, however, to discover his whereabouts by sending out linemen to patrol the line; but his tracks were well concealed, and it was only after the intruder had left that we found the place where our wire had been tapped. He had made the secret connection by means of fine silk-covered magnet wire, in such a manner as to conceal the joint almost entirely. Meantime, Burnside's cipher-operator was temporarily absent from his post, and we had recourse to a crude plan for concealing the text of telegrams to the Army of the Potomac, which we had followed on other somewhat similar occasions when we believed the addressee or operator at the distant point (not provided with the cipher-key) was particularly keen and alert. This plan consisted primarily of sending the message backward, the individual words being misspelled and otherwise garbled. We had practised on one or two dispatches to Burnside before the Confederate operator was discovered to be on the wire, and were pleased to get his prompt answers, couched also in similar outlandish language, which was, however, intelligible to us after a short study of the text in each case. Burnside and ourselves soon became quite expert in this home-made cipher game, as we all strove hard to clothe the dispatches in strange, uncouth garb.

"In order to deceive the Confederate operator, however, we sent to Burnside a number of cipher messages, easy of translation, and which contained all sorts of bogus information for the purpose of misleading the enemy. Burnside or his operator at once surmised our purpose, and the general thereupon sent us in reply a lot of balderdash also calculated to deceive the uninitiated.

"It was about this time that the following specially important despatch from Lincoln was filed for transmission:

Executive Mansion, Washington,
November 25, 1862. 11:30 AM.

MAJOR-GENERAL BURNSIDE, Falmouth, Virginia: If I should be in boat off Aquia Creek at dark to-morrow (Wednesday) evening, could you, without inconvenience, meet me and pass an hour or two with me?

A. Lincoln.

"Although the Confederate operator had said good-by several days before, we were not sure he had actually left. We therefore put Lincoln's telegram in our home-made cipher, so that if the foreign operator were still on our wire, the message might not be readily made out by the enemy. At the same time extra precautions were taken by the Washington authorities to guard against any accident to the President while on his visit to Burnside. No record is now found of the actual text of this cipher-despatch, as finally prepared for transmission, but going back over it word for word, I believe the following is so nearly like it as to be called a true copy:"

Washington, D. C., November 25, 1862

BURNSIDE, Falmouth, Virginia: Can Inn Ale me withe 2 oar our Ann pas Ann me flesh ends N. V. Corn Inn out with U cud Inn heaven day nest Wed roe Moore Tom darkey hat Greek Why Hawk of Abbott Inn B chewed I if. BATES."

This sort of subterfuge is hardly worthy of becoming embalmed in the official records of the war—and apparently it wasn't. But several years later, one of identical nature did become so embalmed, for the message appears on page 236, Vol. 45, of "Telegrams received by the Secretary of War":

Hq. Armies of the U. S., City Point, Va.,
8:30 a. m., April 3, 1865

TINKER, War Department: A. Lincoln its in fume a in hymn to atart I army treating there possible if of cut too forward pushing is He is so all Richmond aunt confide is Andy evacuated Petersburg reports Grant morning this Washington Secretary War. BECKWITH.

Both Plum and Bates cite the foregoing telegram and their comments are interesting if not very illuminating. Plum says merely: "By reading the above backward with regard to the phonetics rather than the orthography, the meaning will be apparent." Bates says:

"The probable reason for adopting this crude form was to insure its reaching its destination without attracting the special attention of watchful operators on the route of the City Point-Washington wire, because at that crisis every one was on the *Qui vive* for news from Grant's advancing army, and if the message had been sent in plain language, the important information it conveyed might have been overheard in its transmission and perhaps would have reached the general public in advance of its receipt by the War Department.

"It is not necessary to give the translation of this cipher-message. To use a homely term, 'Any one can read it with his eyes shut.' In fact, the easiest way would be for one to shut the eyes and let some one else read it backward, not too slowly. The real wording then becomes plain."

Can you imagine for one moment that a "cryptogram" of such simplicity could not be read at sight by any USMTC operator, even without having someone read it to him backward? Such a "cryptogram" is hardly worthy of a schoolboy's initial effort at preparing a secret message. But I assure you that I did not make this story up, nor did I compose the cryptogram.

Ruminating upon what I have shown and told you about the cryptosystems used by both sides in the Civil War, do you get the feeling, as I do, that the cryptologic achievements of neither side can be said to add lustre to undoubtedly great accomplishments on the battlefield? Perhaps this is a good place to make an appraisal of the cryptologic efficiency of each side.

First, it is fair to say that we can hardly be impressed with the cryptosystems used by either side. The respective Signal Corps at first transmitted by visual signals messages wholly in plain language; such messages were often intercepted and read straight away. Then both sides began enciphering such messages, the Signal Corps of the Federal Army using a cipher disk invented by the Chief Signal Officer, the Signal Corps of the Confederate Army using the Vigenère cipher. In both cases the use of cryptography for tactical messages was quite inept, although it seems that from time to time the Federal signalmen had better success with the Vigenère-enciphered visual messages of the Confederate signalmen that the latter had with the disk-enciphered messages of the Union signalmen.

With regard to the cryptosystem used by the Confederate Signal Corps, although there may initially have been cases in which monoalphabetic substitution alphabets were used, such alphabets were probably drawn up by agreement with the signal officers concerned and changed from time to time. Nowhere have I come across a statement that the Myer disk or something similar was used. In any event, messages transmitted by visual signals were read from time to time by Union signalmen, the record showing a number of cases in which the latter "worked out the rebel signal code"—meaning, of course, that the substitution alphabet involved was solved. When did the Confederate Signal Corps begin using the Vigenère cipher? The answer seems to be quite clear. In a letter dated 6 June 1888 from General J. H. Alexander (brother of General E. P.) to J. Willard Brown[11] we find the following statements:

"At the first inauguration of the Signal Service in the Confederacy, I, having received in the first place the primary instruction from my brother, Gen. E. P. A., then a colonel on Beauregard's staff near the Stone Bridge at Manassas, was assigned the duty of preparing a confidential circular of instruction for the initiation of officers and men, in this branch. I did prepare it, in Richmond, in early spring, 1862, and surrendered the copy to Hon. James A. Seddon, the then Secretary of War at Richmond. It was issued in form of a small pamphlet. *I had attached a table for compiling cipher dispatches—which was printed with the rest of the matter—and the whole was issued confidentially to the officers newly appointed for signal duty.*[12]

I have italicized the last sentence because I think that the "table for compiling cipher dispatches" can refer only to the Vigenère square table, for that and only that sort of table is even mentioned in accounts of the ciphers used by the Confederacy. One could, of course, wish that the writer had given some further details, but there are none. However, the statement about the table is sufficiently explicit to warrant the belief that it was General J. H. Alexander who officially introduced the Vigenère square into Confederate cryptography, al-

[11] Op. cit., p. 206.

[12] My emphasis.—W.F.F.

though he may have obtained the idea from his brother, since he states that he "received in the first place the primary instruction from my brother."

In the Federal Signal Corps it is quite possible that the polyalphabetic methods Myer cites in his *Manual* for using his cipher disk (changing the setting with successive words of a message) were used in some cases, because there are found in the record several instances in which the Confederate signalmen, successful with monoalphabetic encipherments, were completely baffled. One is warranted in the belief that it was not so much the complexities introduced by using a key word to encipher successive *words* of the plain text as it was the lack of training and experience in cryptanalysis which hampered Confederate signalmen who tried to solve such messages. In World War I a German Army system of somewhat similar nature was regularly solved by Allied cryptanalysts, but it must be remembered, in the first place, that by 1914 the use of radio made it possible to intercept volumes of traffic entirely impossible to obtain before the advent of radiotelegraphy; and, in the second place, would-be cryptanalysts of both sides in the Civil War had nothing but native wit and intelligence to guide them in their work on intercepted messages, for there were, so far as the record goes, no training courses in *cryptanalysis* on either side, though there were courses in cryptography and signaling. It would seem to cryptanalysts of 1961, a century later, that native wit and intelligence nevertheless should have been sufficient to solve practically every message intercepted by either side, so simple and inefficient in usage do the cryptosystems employed by both sides appear today.

No system employed by the Federals, either for tactical messages (Signal Corps transmissions) or strategic messages (USMTC transmissions) would long resist solution today, provided, of course, that a modicum of traffic were available for study. Although technically far less secure in actual practice than properly enciphered Vigenère messages, the route ciphers of the USMTC seem to have eluded the efforts of inexpert Confederate cryptanalysts. Ex-USMTC operators make the statement that none of their messages was ever solved and that the Confederates published intercepted messages in Southern newspapers in the hope that somebody would come forward with a solution; yet it must be remembered that those operators were Northerners who were very naturally interested in making the achievements of the Union operators, both in cryptography and in cryptanalysis, appear more spectacular than they really were. And it is probable that they wrote without having made a real effort to ascertain whether the Confederates did have any success. A "real effort" would have been a rather imposing undertaking then—as it still is, I fear. Now it must be presumed that if Confederate operators had succeeded in solving intercepted traffic of the USMTC they would have recorded the facts to their own credit. But in his seven volumes on the campaigns of Lee and his lieutenants, Douglas S. Freeman does not mention a single instance of interception and solution of telegraphic messages of the Union. Perhaps Freeman was seeking 100% confirmation, which is too much to expect in a field of such great secrecy. This failure of the Confederate cryptanalysts is the more astonishing when we know that copies of the USMTC cipher books were captured and that, therefore, they must have become aware of the nature of the route ciphers used by the USMTC, unless there was a lack of appreciation of the value of such captures and a failure to forward the books to the proper authorities, who could hand them over to their experts. In those books the USMTC route ciphers would have been seen in their naive simplicity, complicated only by the use of "arbitraries" or code equivalents, but hardly to the degree where all messages would be impossible to solve. It seems to me that there can be only four possible explanations for this failure to solve the USMTC route ciphers. Let us examine them in turn.

First, it is possible that there was not enough intercept traffic to permit solution. But this is inadequate as an explanation. The route cipher is of such simplicity that "depth" is hardly an absolute requirement—a single message can be solved, and its intelligibility will be determined to a large degree by the number of "arbitraries" it contains. Where there are many, only the dim outlines of what is being conveyed by the message may become visible; where there are few or even none, the meaning of the messages becomes fairly evident. But the abundant records, although they contain many references to intercepts, fail to disclose even one

stance of solution of a USMTC message. Thus we are forced to conclude that it was not a lack of intercept traffic which accounts for lack of success by the Confederates with USMTC messages, but some other factor.

Second, the lack of training in cryptanalysis of Confederate cryptanalysts might have been the reason why Confederate signalmen failed to solve the messages. This sounds plausible until we look into the matter with a critical spirit. Solution of route ciphers requires little training; native wit and intelligence should have been sufficient. The degree of intelligence possessed by Confederate officers and men was certainly as high as that of their Union counterparts who were up against a technically far superior cryptosystem, the Vigenère. We may safely conclude that it was not lack of native wit and intelligence that prevented them from solving messages enciphered by the USMTC route ciphers.

Third, it is possible that Confederate high commanders were not interested in communication-intelligence operators or in gathering the fruits of such operations. Such an explanation seems on its face fatuous and wholely unacceptable. We know of the high estimate of value field commanders placed upon the interception and solution of tactical messages transmitted by visual signaling; but an appreciation of the extraordinary advantages of learning the contents of enemy communications on the strategic level may have been lacking. My colleague, Mr. Fishel, thinks that "intelligence consciousness" and "intelligence sophistication" were of a very low order in the Union Army, and of a markedly lower order in the Confederate Army. But to us, in 1961, to disregard the advantages of a possible reading of strategic messages seems almost incredible, and I am inclined to discount this sort of explanation.

Fourth, it is possible that Confederate cryptanalysts were far more successful in their efforts to solve USMTC transmissions than present publicly available records indicate; that Confederate commanders obtained great advantages from their communication-intelligence operations; that they fully recognized the supreme necessity of keeping this fact and these advantages secret; and that the Confederate States Government adopted and enforced strict communication-intelligence security regulations, so that the truth concerning these matters has not yet emerged. Let it be noted in this connection that very little information can be found in the public domain today about Allied cryptanalytic successes during World War I; and were it not for the very intensive and extensive investigations in the matter of the Japanese attack on Pearl Harbor on 7 December 1941, very little, if any, information would be known to the public about British and American successes in communication intelligence during World War II. Immediately following the capture of Richmond and before Confederate records could be removed to a safe place, a great fire broke out and practically all those records were destroyed. It is possible that this is one of the reasons why the records of their communication-intelligence successes have never come to light. But it is also possible that Confederate cryptanalysts kept their secrets to themselves. We know that the records possessed or taken by certain Confederate leaders have been gone over with great care and attention, but what happened to those retained by other Confederate leaders such as the Secretary of War Seddon, or his predecessor Judah P. Benjamin, who later became Secretary of State, and others? Here is a fascinating speculation and one which might well repay careful, painstaking research in the voluminous records of our National Archives. I shall leave the delving into those records to some of you young and aspiring professional cryptanalysts who may be interested in undertaking such a piece of research. With this thought I bring this lecture to its close.

Lecture V

For a half century following the close of the Civil War, cryptology in the United States enjoyed a period of hibernation from which it awoke at long last about 1914, not refreshed, as did Rip Van Winkle, but weaker. This is perhaps understandable if we take into account the fact that the United States was able to enjoy a long era of peace, broken only briefly by the short war with Spain in 1898. For over three decades there was little or no need for cryptography in the United States Government, except for the communications of the Department of State. The military and naval services apparently felt that in time of peace there was no need for either cryptography or cryptanalysis, and since it looked as though the U.S. was going to enjoy peace for a long, an indefinitely long time, those services did not think it necessary or desirable even to engage in theoretical cryptologic studies. Of course, the War Department and the Army still had those route ciphers and cipher disks described in the preceding lecture; the Navy Department and the Navy had cipher disks for producing simple monoalphabetic ciphers; and the Department of State had a code more-or-less specifically designed for its communications. Separated from Europe by the broad Atlantic, and mindful of General Washington's policy of noninvolvement in the problems of European diplomacy, America followed the traditional and easy course of isolationism. The quarrels among the countries in Europe were none of our business, and America turned its back to them for a half century, uninterested and unconcerned.

There was, however, in this long hibernating period in U.S. cryptology one episode of particular interest. It concerned a Presidential election in which the circumstances paralleled the election of 1960, when the very small popular-vote majority of the Democratic candidate suggested a possible upset in the electoral college voting. The episode to which I refer here occurred nearly a century ago, in the Presidential election of 1876, in which Democratic candidate Samuel J. Tilden was pitted against Republican candidate Rutherford B. Hayes. On the basis of early evening election returns Tilden seemed to be easily the winner. Indeed, just before going to bed on election night, 8 November 1876, Hayes conceded the election to Tilden, and the newspapers next morning followed this lead and reported a Tilden victory. But when final tallies began coming in they showed that the closeness of the popular vote made Tilden's victory not so sure as his supporters had calculated, and they therefore began to become apprehensive about their candidate's victory. Their apprehensions were valid because of our peculiar system of electing a president, peculiar because it is the electoral and not the popular vote which determines who is to be the next occupant of the White House as President. Two days after the people had voted, it became clear that Tilden would have 184 electoral votes, just one vote short of insuring victory, whereas Hayes would have only 163, thus needing 22 more. The Tilden supporters began a frantic campaign to get that one additional vote they needed, and they didn't hesitate to try every possible ruse to obtain it, including bribery, a rather serious piece of business and one obviously requiring a good deal of secrecy, especially in communications. Of course, many telegrams had to be exchanged between the Tilden headquarters in New York City and confidential agents who had to be sent to certain states where one or more electoral votes could perhaps be purchased; telegrams also had to be exchanged among those secret agents in the field. About 400 telegrams were exchanged and some 100 of these were in cryptographic form. Communication difficulties caused two almost consummated bribery deals to fall through; and a third deal failed because the electors proved to be honest Republicans not susceptible to monetary temptation. The existence of these telegrams, however, remained unknown to the public for months. We shall come to them later.

Despite the efforts of the Tilden supporters, the outcome of the election remained in doubt because four states, Florida, South Carolina, Louisiana and Oregon, each sent two groups of

electors, an event not foreseen or provided for in the Constitution. A crisis arose and the country seemed to be on the verge of another civil war. By an Act of 29 January 1877, Congress created a special electoral commission to investigate and decide upon the matter of the disputed electoral votes in the four states. Recounts of votes in certain election precincts were made, sometimes aided by soldiers of the Federal Army. The commission voted in favor of the Hayes electors in each case, and having obtained the needed 22 electoral votes, Hayes entered the White House.

It was only some months afterward that the telegrams to which I have referred were brought to light, and a situation arose which Congress felt it had to look into. Somehow or other, in the summer of 1878, copies of those telegrams had come into the possession of a Republican newspaper in New York, *The Tribune*. Interested only in ascertaining the truth, the editor put two members of his staff on the job, and they succeeded in solving those telegrams which were in cipher.

Various books dealing with the political aspects of his intriguing story are available in public libraries, but those of you who are interested only in its cryptologic aspects will find excellent material in the following four documents:

[1] "The Cipher Dispatches", *The New York Tribune*, Extra No. 44, New York, (14 January) 1879.

[2] Hassard, John R. G., "Cryptography in Politics," *The North American Review*, Vol CXXVIII, No. 268, March 1879, pp 315–325.

[3] Holden, Edward S., *The Cipher Dispatches*, New York, 1879.

[4] U. S. House Miscellaneous Documents, Vol 5, 45th Congress, 3rd Session, 1878–79.

The last-mentioned item, that put out by the Congressional House Committee which had been designated to conduct the investigation (and which was named "The Select Committee ... alleged frauds in the Presidential Election of 1876"), is of special interest. In the course the investigation, the Committee solicited the technical assistance of Professor Edward S. Holden, of the United States Naval Observatory in Washington, the author of the third item listed above, who I believe was a captain in the Navy and had specialized in mathematics. *The Tribune* had brought him into the picture by asking his help when solution seemed hopeless, but it turned out that Mr. John R. G. Hassard, the chief of *The Tribune* staff, and his colleague, Colonel William M. Grosvenor, also of that staff, solved the ciphers independently and, in fact, shortly before Prof. Holden solved them, although it was the latter that the Congressional Committee called upon to explain matters, as would only be natural under the circumstances.

Professor Holden's testimony, in which he set forth his solution of the nearly 200 cryptograms entered in evidence, is presented in the form of a letter to the Committee, dated 21 February 1879. In it he described and explained all the cryptosystems used, together with their keys and full details of their application. In that letter, Professor Holden makes the following statement: "By September 7, 1878, I was in possession of a rule by which any key to the most difficult and ingenious of these [ciphers] could infallibly be found." Most of the ciphers involved word transpositions and Holden worked out the keys but in this he had been anticipated by the *Tribune* cryptanalysts. There were in all 10 different keys, two for messages of 10, 15, . . . words, up to and including two for messages of 30 words. On the opposite page will be found the complete "Table of Keys."

You may be wondering why there are two transposition keys for each length of message from 10 to 30 words, in multiples of 5. The two keys constituting a pair are related to each other, that is, they bear a relationship which Mr. Hassard, one of the *Tribune* cryptanalysts, termed "correlative," but which we now would call an "encipher-decipher" or a "verse-inverse" relationship. Either sequence of a correlative pair of sequences may be used to encipher a message; the other can then be used to decipher the message. For example, key III consists of the following series of numbers: 8-4-1-7-13 . . ., etc., and the correlative, key IV, is 5-12-2-6 . . ., etc. A cipher message of 15 words can be deciphered either by (1) number-

TABLE OF KEYS

10 Words		15 Words		20 Words		25 Words		30 Words	
I	II	III	IV	V	VI	VII	VIII	IX	X
9	4	8	3	6	12	6	18	17	4
3	7	4	7	9	18	12	12	30	26
6	2	1	12	3	3	23	6	26	23
1	9	7	2	5	5	18	25	1	15
10	6	13	6	4	4	10	14	11	8
5	3	5	8	13	1	3	1	20	27
2	8	2	4	14	20	17	16	25	16
7	10	6	1	20	16	20	11	5	30
4	1	11	11	19	2	15	21	10	24
8	5	14	15	12	19	19	5	29	9
		9	9	17	13	8	15	27	5
		3	14	1	10	2	2	19	19
		15	5	11	6	24	17	28	17
		12	10	15	7	5	24	24	25
		10	13	18	14	11	9	4	22
				8	17	7	22	7	28
				16	11	13	7	13	1
				2	15	1	4	18	18
				10	9	25	10	12	12
				7	8	22	8	22	6
						9	23	21	21
						16	20	15	20
						21	3	3	29
						14	13	9	14
						4	19	14	7
								2	3
								6	11
								16	13
								23	10
								8	2

Figure 70.

ing its words consecutively and then assembling the words in the other 8–4–1–7–13, or by (2) writing the sequence 3–7–12–2–6 . . . above the words of the cipher message and then assembling the numbered words according to the sequence 1–2–3–4–5 . . . . Thus, there were, in reality, not ten different transposition keys but only five. In the case of each pair of keys, one of them must have been the basic sequence, the other the inverse of it, or at least some derivative thereof.

I suspect that the basic or "verse" sequences of numbers were not drawn up at random but were derived from words or phrases; and I think that they were the odd-numbered ones because, as you will notice, it is in the odd-numbered keys that the *positions of sequent digits* reflect the presence of an underlying key word or phrase; this is not true in the even-numbered keys. I have not seriously attempted to reconstruct the key words, but perhaps some of you may like to try and will succeed in doing so.

In addition to transposition, this system involved the use of "arbitraries" to represent certain words, the names of important persons and places, numerals, etc. There were also a few nulls.

Professor Holden adds some comments about this system which are worth quoting:

> "The essence of this ingenious and novel system consists in taking apart a sentence written in plain English (dismembering it, as it were) and again writing all the words in a new order, in which they make no sense. The problem of deciphering it consists in determining the order according to which the words of the cipher should be written in order to produce the original message.

"There is one way, and only one way, in which the general problem can be solved, and that is to take two messages, A and B, of the same number of words, and to number the words in each; then to arrange message A with its words in an order which will make sense, and to arrange the words of message B in the same order. There will be one order—and only one—in which the two messages will simultaneously make sense. This is the key."

Here, in a nutshell, we find the basic theory of solving transposition ciphers by anagramming messages of the same length, explained in a most succinct manner.

It appears that Professor Holden, clever as he was, did not note the verse-inverse relation in each pair of sequences, or if he did, he failed to mention it in his testimony. However, Hassard [2] specifically points this out.

There were enough messages in this system to make it possible to solve code words used, as well as to recognize a few nulls which were occasionally added to complicate matters. Hence, the most complicated of the cryptosystems involved in this bizarre political episode were solved.

Another system used by the conspirators employed a biliteral substitution, that is, one in which a pair of cipher letters represents a single letter. This substitution was based upon a 10 × 10 checkerboard. Apparently neither Professor Holden nor the *Tribune* cryptanalysts recognized the latter principle, nor did they find that the coordinates of the checkerboard employed a key phrase, nor did they realize that the same checkerboard, with numerical coordinates, was used for a numerical substitution alphabet in which pairs of digits represent letters of the alphabet.

Here are two of the messages exchanged by the conspirators, one in the letter cipher, the other in the figure cipher. The messages are long enough for solution. Try to solve them, reconstruct the matrix and find the key phrase from which the coordinates of the matrix were derived. It should amuse you by its appropriateness.

The message in letter cipher is as follows:

Jacksonville, Nov. 16 (1876)

Geo. R Raney, Tallahassee:

PP YY EM NS HY YY PI MA SH NS YY SS IT EP AA EN SH NS
SE US SH NS MM PI YY SN PP YE AA PI EI SS YE SH AI NS
SS PE EI YY SH NY NS SS YE PI AA NY IT NS SH YY SP YY
PI NS YY SS IT EM EI PI MM EI SS EI YY EI SS IT EI EP
YY PE EI AA SS IM AA YE SP NS YY IA NS SS EI SS MM PP
NS PI NS SN PI NS IM IM YY IT EM YY SS PE YY MN NS YY
SS IT SP YY PE EP PP MA AA YY PI IT L'Engle goes
up tomorrow.

(Signed) Daniel

The example in figure cipher is as follows:

Jacksonville, Nov. 17 (1876)

S. Pasco and E. M. L'Engle:

84 55 84 25 93 34 82 31 31 75 93 82 77 33 55 52 93 20
90 66 77 65 33 84 63 31 31 93 20 82 33 66 52 48 44 55
42 82 48 89 42 93 31 82 66 75 31 93

(Signed) Daniel

There were several other systems involved in this episode of political skullduggery, but I am going to have to pass them by because they hardly deserve attention in this brief history. I do, however, want to call your attention to the very close resemblance between the word-

transposition ciphers characterized by Professor Holden as the "most difficult and ingenious" of the ciphers he solved, and the USMTC route ciphers described in the preceding lecture. Yet, not only he but also the *Tribune* amateur cryptanalysts solved those ciphers without too much difficulty, even though they were technically more complex. I think their work on the Tilden ciphers clearly confirms my own appraisal of the weakness of the route ciphers used by the USMTC in the Civil War.

After this digression into the realm of what may be called political cryptology, let us now go on with our military cryptologic history. I have already told you that the Department of State used a code for cryptographic communications in the years following the Civil War, but I do not know what it was like. It may even have been an adapation of some commerical code. But in an article entitled "Secret Writing," which appeared in *Century Magazine*, Vol. LXXXV, November 1912, No. 1, a man named John H. Haswell, apparently at that time a code clerk in the Department, referred to a new code of the department in the following terms:

> "The cipher of the Department of State is the most modern of all in the service of the Government. It embraces the valuable features of its predecessors and the merits of the latest inventions. Being used for every species of diplomatic correspondence, it is necessarily copious and unrestricted in its capabilities, but at the same time it is economic in its terms of expression. It is simple and speedy in its operation, but so ingenious as to secure absolute secrecy. The construction of this cipher, like many ingenious devices whose operations appear simple to the eye but are difficult to explain in writing, would actually require the key to be furnished for the purpose of an intelligible description of it."

Only four years later a certain telegraph operator and code clerk of the State Department proved how vulnerable the Department's system of enciphered code really was. His name was Herbert O. Yardley (Fig. 71) and many of you may know a bit about him as the author of a famous or infamous book (depending upon whose side you're on) entitled *The American Black Chamber*, published in Indianapolis by the Bobbs-Merrill Co. in 1931. So far as I know it is the only book which cannot legally be reprinted in the United States because a special law passed in 1934 makes it a criminal offense to do so. That is quite a story in itself, but I cannot tell it now. If you happen to own a copy of the first and only American edition, don't let it get away from you, because you can only obtain another copy of it by a more-or-less "under the table" deal; but you may be able to purchase a British edition, or a translation in French, in Japanese, or in other languages, for the book was sensational. But to return to that State Department cryptosystem, which was considered by Haswell as giving absolute secrecy and which was readily solved by Yardley, here is what appears on the cover page of Yardley's 21-page typewritten analysis and solution of the system:

> THEORY AND PRACTICE OF ENCIPHERED CODE
> State Department Problems
> I, II, and III
>
> *Note:* The following was written in March 1916 and, so far as I can learn, is the first successful attempt to solve a problem in enciphered code.
>
> H. O. Yardley

Yardley was quite wrong in thinking that his was the first successful attempt to solve a problem in enciphered code, for in Europe more complicated cases were often solved, and I imagine that European cryptanalysts could have read, and perhaps did read, State Department messages as a more or less routine matter. I think I am warranted in assuming that what I have just said is true because, in Europe, cryptanalytic studies were going on apace during the years of American neglect of such studies. The turning point from neglect to a renaissance of interest in cryptologic studies in Europe is said by some authorities to have been about the year 1850; but we must confine ourselves for the most part to developments in America, in order to keep this lecture within bounds of what can be told within a limited time.

In our Navy it seems that simple monoalphabetic ciphers continued in use until the middle of the eighties, when several naval officers were designated to prepare a more suitable system;

Figure 71.

based upon a code particularly designed for naval communications. The system they worked out was embodied in a very large codebook, 18″ long, 12″ wide and 2″ thick, which had the official title *The U. S. Navy Secret Code*. There was also an accompanying but separate cipher book, almost as large, and designated as *The Book of Key Words*. In addition to these was a third large book called *General Geographical Tables*. The system was placed into effect on 1 December 1887. Later I will show you a most historic message sent in that system of secret communication, which today impresses one as being extraordinarily clumsy and slow.

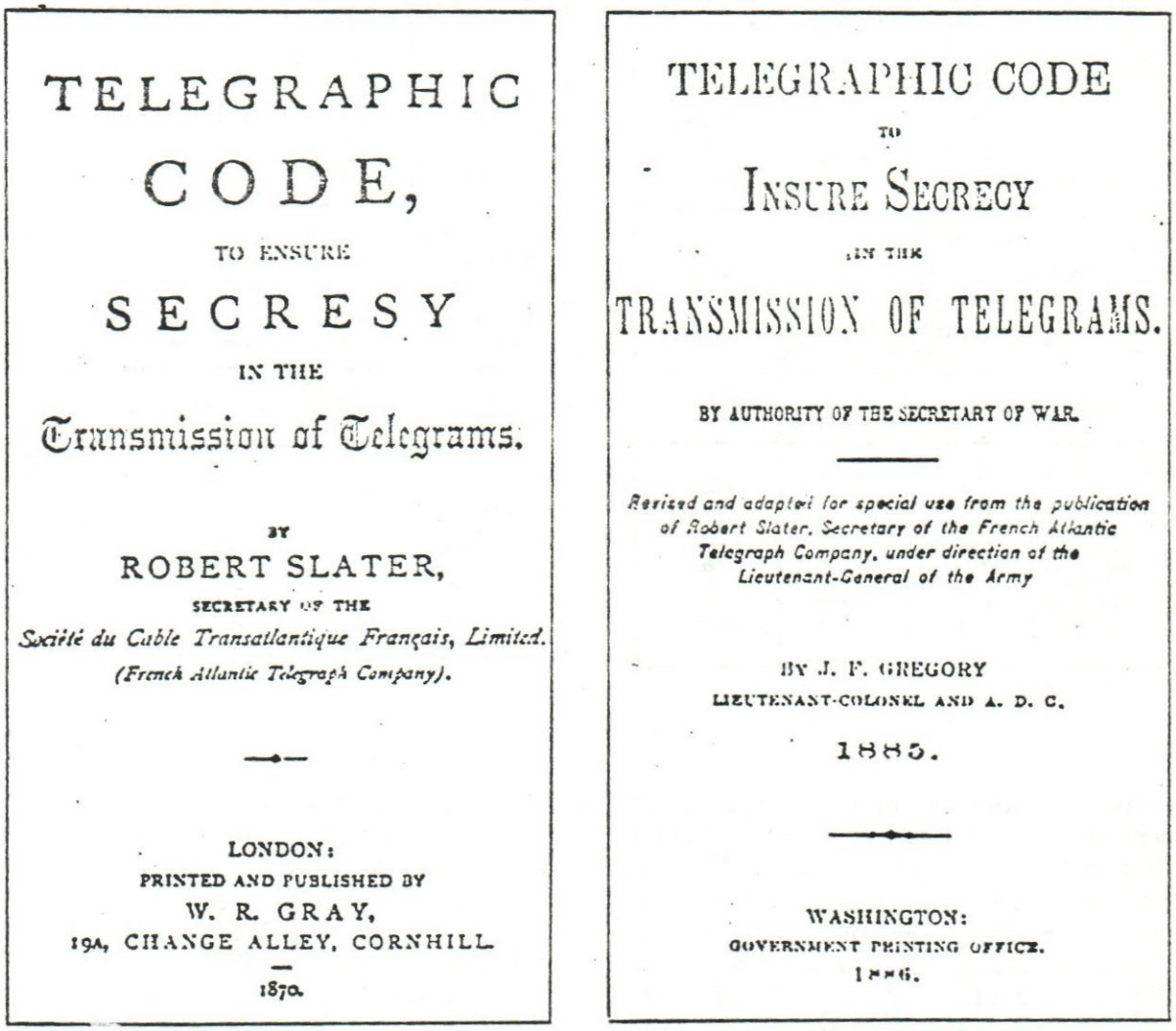
In our Army, in the middle eighties, a code was also prepared. It is no pleasure to have to tell you that its composition and format hardly shed laurels upon those responsible for its reproduction, because it was merely a simple and acknowledged adaptation of a commercially available small code for use by the general public, first published in 1870 with the title *Telegraphic Code to Ensure Secresy in the Transmission of Telegrams*. It had been compiled by the Secretary of the French Trans-Atlantic Telegraph Company, a man named Robert Slater, and it became known everywhere as "Slater's Code." As to the nature of the code, I will quote from Slater's own "Short explanation of the mode of using this work," in a sort of preface to the 2nd Edition:

> "It is a numbered Telegraphic Dictionary of the English language, of which each word bears a distinctive No. (from 00001 to 25000, with exactly 100 words per page), and the method of using it is by an interchange of Nos., in accordance with a private understanding between correspondents that a further No. is to be added to or deducted from the number in the code, of the word telegraphed or written, to indicate the real-word intended, thus a "Symbolic" or "Dummy Word" is telegraphed, the meaning of which can only be read by those who have the key to the secret of how many should be added to or deducted from the number in the Code, of the "Dummy Word" to find the word meant." (Punctuation as in the original).

Here we have a sentence of 116 words. Though it is rather long and a bit murky, I think you will gather its import. The system as thus far described is what we now call the additive or subtractive method. But in the detailed instructions Slater goes one step further and suggests that instead of telegraphing the code number resulting from addition or subtraction of a

key number, the word standing alongside the sum (or difference) of the mathematical operation be sent as the telegraphic code word. Slater's code must have met with popular acclaim because by 1906 it was in its fifth edition. A copy of the second edition (1870), is in my collection. As for a copy of the very first edition, not even the Library of Congress has one, it's that scarce.

To get on with the story, in 1885 the War Department published an adaptation of Slater's Code for its use and the use of the Army. Here is a picture of its title page, the only difference between it and that of Slater's Code being in the spelling of the word "secrecy," as you can easily see in the picture I show you next (Fig. 72). It would appear that the "compiler" of this code, Col. Gregory, was just a bit deficient in imagination, because not only did he merely



TELEGRAPHIC

CODE,

TO ENSURE

SECRESY

IN THE

Transmission of Telegrams.

BY

ROBERT SLATER,

SECRETARY OF THE

Société du Cable Transatlantique Français, Limited.

(French Atlantic Telegraph Company).

LONDON:

PRINTED AND PUBLISHED BY

W. R. GRAY,

19A, CHANGE ALLEY, CORNHILL.

1870.

TELEGRAPHIC CODE

TO

INSURE SECRECY

IN THE

TRANSMISSION OF TELEGRAMS.

BY AUTHORITY OF THE SECRETARY OF WAR.

Revised and adapted for special use from the publication of Robert Slater, Secretary of the French Atlantic Telegraph Company, under direction of the Lieutenant-General of the Army

BY J. F. GREGORY

LIEUTENANT-COLONEL AND A. D. C.

1885.

WASHINGTON:

GOVERNMENT PRINTING OFFICE.

1886.

Figure 72.

borrow the basic idea and format of Slater's Code, but even when it came to explaining and giving examples of enciphering the code groups, the Colonel used not only the identical rules but also the very same wording and even the very same type of examples of transformations that are found in Slater's original. Let me show an example in Slater's code side by side with the same example in Gregory's:

EXAMPLES. vii

EXAMPLE I.

The Queen is the supreme power in the Realm.

Add any number below 25000 (say, for instance,) 5555 to the numbers opposite to those words it is desired to transmit. Where the result exceeds 25000, deduct that number, or, in other words, commence the alphabet again.

Word to be transmitted.	No. in Vocabulary.	Plus 5555.	Representing in Vocabulary.
The	22313	27868	Bounteous
Queen	18095	23650	wedge
is	12370	17925	purifying
the	22313	27868	bounteous
supreme	21953	27508	biography
power	17056	22611	transparent
in	11426	16981	posed
the	22313	27868	bounteous
Realm	18419	23974	yoke

The message being transmitted:—

Bounteous wedge purifying bounteous biography transparent posed bounteous yoke,

the receiver reverses the operation, adding 25000 to the number where it is below that to be deducted.

Word received.	No. in Vocabulary.	Minus 5555.	Representing in Vocabulary.
Bounteous	02868	22313	The
wedge	23650	18095	Queen
purifying	17925	12370	is
bounteous	02868	22313	the
biography	02508	21953	supreme
transparent	22611	17056	power
posed	16981	11426	in
bounteous	02868	22313	the
yoke	23974	18419	Realm

VI EXAMPLES.

EXAMPLE I.

War is a punishment whereof death is the maximum.

Add any number below 25000 (say, for instance, 3333) to the numbers opposite to those words it is desired to transmit. Where the result exceeds 25000, deduct that number, or, in other words, commence the alphabet again.

Word to be transmitted.	Number in vocabulary	Plus 3333.	Representing in vocabulary.
War	25724	27057	Barker
is	12373	15706	ovation
a	06001	09334	cairn
punishment	17903	21236	sousing
whereof	23937	27270	begetting
death	06202	09535	frequent
is	12373	15706	ovation
the	22527	25860	agape
maximum	14032	17365	priggish

The message being transmitted reads—

Barker ovation cairn sousing begetting frequent ovation agape priggish,

the receiver reverses the operation, adding 25000 to the number where it is below that to be deducted.

Word received.	Number in vocabulary.	Minus 3333.	Representing in vocabulary.
Barker	02057	25724	War
ovation	15706	12373	is
cairn	09334	06001	a
sousing	21236	17903	punishment
begetting	02270	23937	whereof
frequent	09535	06202	death
ovation	15706	12373	is
agape	00860	22527	the
priggish	17365	14032	maximum

Figure 73.

You will note that Col. Gregory just couldn't use the same text for his examples of encipherment that Slater used, which was: "The Queen is the supreme power in the Realm." Instead he used the enigmatic text: "War is a punishment whereof death is the maximum."[1]

All the other methods and examples of encipherment in the two codes are practically identical. Colonel Gregory gives credit in the following terms to a civilian aide in his great work: "The labor of compiling the new vocabulary has been performed by Mr. W. G. Spottswood." What did the latter do? Well, Mr. Spottswood's work consisted in casting out from Slater's list such words as ABALIENATE and ABANDONEE and replacing them with such words as ABATEMENT and ABATIS. This sort of work must indeed have been arduous. I'm sorry to appear to be so critical of the performance of my predecessors in the construction of codes and code systems for War Department and Army usage, but I feel sure you will agree that more imagination and ingenuity could have been employed than were used by Colonel Gregory and Mr. Spottswood.

[1] I wonder what that sentence means. It sounds sort of "anti-American" to me. Punishment to whom? To the soldiers and sailors and airmen who defend our country? If not to them, then to whom? To the people of a whole nation fighting for liberty? I just don't understand the sentence. Do you?

Col. Gregory prepared a confidential letter addressed to Lieut. General Sheridan, "Commanding Army of the U.S.," to explain the advantages of the new code. But in this letter Col. Gregory quotes very largely from Holden's little brochure [3] and deals almost solely with the ways in which additional security may be gained by changing the additives to the code numbers in Slater's Code. For example, for all messages sent in January add 111; for all messages sent in February add 222, in March 333, etc. Another suggested way: "Send out a simple message in ordinary English: Add 1437 to all ciphers until further orders."

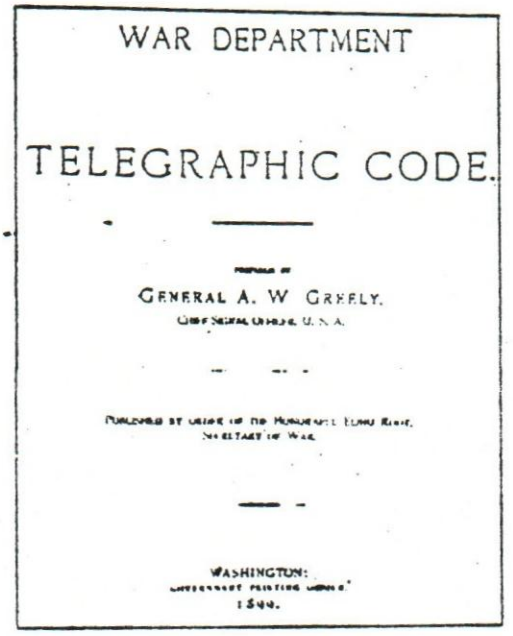
Believe it or not, this was the code that the War Department and the Army used during the Spanish-American War. It was apparently used with a simple additive, because in a copy in my collection the additive is written on the inside of the front cover. It is 777; perhaps it was the additive for the month of July, but the number 777 was written in ink, so it may have been the permanent additive for the whole of the war. In pages 41–42 of *The American Black Chamber* the author throws an interesting sidelight on this code system:

> "The compilation of codes and ciphers was, by General Orders, a Signal Corps function, but the war [1917] revealed the unpreparedness of this department in the United States. How much so is indicated by a talk I had with a high officer of the Signal Corps who had just been appointed a military attaché to an Allied country. It was not intended that attachés should actually encode and decode their own telegrams, but as a part of an intelligence course they were required to have a superficial knowledge of both processes in order that they might appreciate the importance of certain precautions enforced in safeguarding our communications.
>
> When the new attaché, a veteran of the old Army, appeared, I handed him a brochure and rapidly went over some of our methods of secret communications. To appreciate his attitude, the reader should understand that the so-called additive or subtractive method for garbling a code telegram (used during the Spanish-American War) is about as effective for maintaining secrecy as the simple substitution cipher which as children we read in Poe's *The Gold Bug*.
>
> He listened impatiently, then growled: "That's a lot of nonsense. Whoever heard of going to all that trouble? During the Spanish-American War we didn't do all those things. We just added the figure 1898 to all our figure code words, and the Spaniards never did find out about it."

Although *The American Black Chamber* abounds with exaggerations and distortions, what the author tells about the inadequacies of United States codes and ciphers in the years just before our entry into World War I are true enough, and Yardley's impatience and satiric comments in this regard, it grieves me to say, are unfortunately fully warranted.

During or perhaps shortly after the end of the Spanish-American War, the War Department must have begun to realize that there were shortcomings in the code based upon Slater's Code, the one which was in current usage and upon which I have already dwelt. On 16 January 1898 the publication of a new War Department Telegraphic Code was authorized by General Orders No. 9. The code was to be prepared under the direction of General A. W. Greely, then Chief Signal Officer of the Army. The cited General Order makes it quite clear that the War Department version of Slater's Code was still in use, but the Western Union Telegraphic Code was to be used in connection with Slater's until the new War Department Code was completed, which apparently was ready in December 1899, when Slater's was withdrawn from use with this statement in General Orders No. 203: "By direction of the Secretary of War, the *Telegraphic Code to Insure Secrecy in the Transmission of Telegrams*, will on and after January 15, 1900, only be used for correspondence in such cases as may be specially ordered by the Secretary of War." On 12 December 1899 the new War Department Code was issued. Here is a picture of its title page (Fig. 74). It comprised a specially-compiled list of tables, words, phrases and sentences to which code numbers and code words were assigned for specific use in War Department and Army communications. The code numbers began with 78201 and went to 95286; the accompanying code words were foreign, outlandishly unusual real words, and artificial words, beginning with KOPERKIES, KOPERKLEURS, KOPERMOLEN, etc., etc., down through the L's, M's and ending with words such as NAZWELGEN, NEANTHE, NEAPELGELB, etc., etc. You may wish to know why the code numbers didn't begin with 00000 and go to 99999; or why the code groups began with K and went for thousands and thousands of words down to N. The answer is that this brand new *War Department Telegraphic Code* was to be used,

as Slater's Code was used, in conjunction with the *Western Union Telegraphic Code*, a code of 3,200 groups beginning with numerical code groups 00000 accompanied by literal code words beginning with BEERKAR, BEERKARREN, BEERMELD . . . and going to KOOTJONGEN, KOOTKRUID, KOOTSPEL. Here is a picture of a typical page in this code (Fig. 75).


WAR DEPARTMENT

TELEGRAPHIC CODE.

GENERAL A. W GREELY.

WASHINGTON:

1890.

Figure 74.

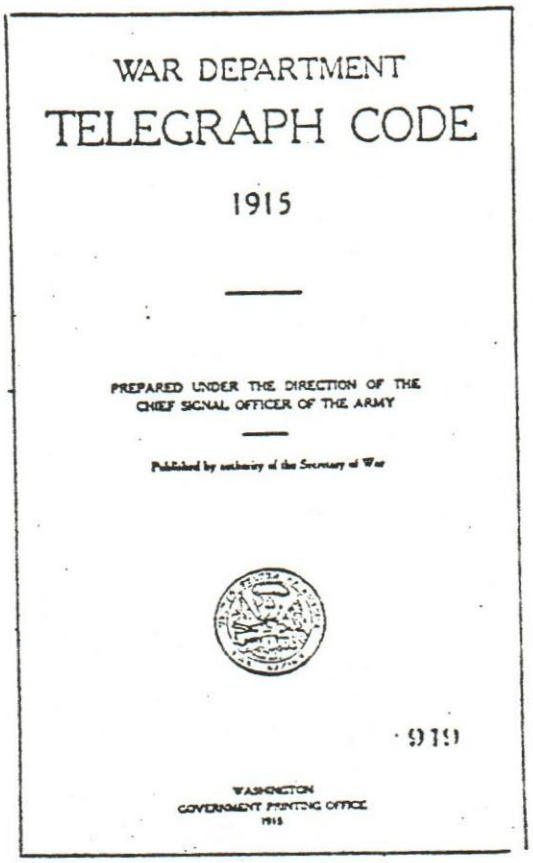
Figure 75.

The introduction to this code explains this puzzling fact.

> "Through lack of time it has been impossible to incorporate in the *War Department Telegraphic Code* all desirable phrases, and in consequence the first 471 pages of the *Western Union Telegraphic Code* now in use by the Army will continue in use as a supplementary code. This affords the Army the telegraphic use of 100,000 code words, of which numbers 1 to 78,201, inclusive, are in the *Western Union Telegraphic Code* and numbers 78,201 to 100,000 are in the *War Department Telegraphic Code.*"

It thus becomes clear that for several years the new War Department Code was to be used in conjunction with the commercially available large *Western Union Telegraphic Code.* This was stated to be for the purpose of economy. For secrecy, the additive or subtractive method was to be used. The futility of such an old and simple method for achieving communication security needs no comment. I wish there were time to read you the instructions in that new *War Department Telegraphic Code* as regards the use of these ciphers for secrecy. They are practically the same as those in the 1885 version of Slater's Code and are unbelievably futile, but what else could be expected when cryptology is relegated to a position in military science far inferior to that of teaching the use of a rifle or bayonet, subjects which are taught, as a rule, by experts? Why was cryptology left to inexperienced amateurs during all those years? Was it stupidity? No, just a lack of appreciation of the importance of secure communications in military operations—and a lack of enough people with the requisite know-how.

How long this combination of two codes continued to be used I don't know. Sometime during the years 1900 to 1915 this absurd system must have proved itself entirely unsatisfactory, for in 1915 another brand new *War Department Telegraphic Code* was put out, under direction of Brigadier General George P. Scriven, the Chief Signal Officer of the Army who succeeded Greeley. Here is a picture of its title page (Fig. 76). The book bears no security



WAR DEPARTMENT

TELEGRAPH CODE

1915

PREPARED UNDER THE DIRECTION OF THE CHIEF SIGNAL OFFICER OF THE ARMY

Published by authority of the Secretary of War

9119

WASHINGTON
GOVERNMENT PRINTING OFFICE
1915

Figure 76.

Figure 77.

classification, for even as late as in 1915 there was no real or definite classification system for security purposes. The instructions recommended certain precautions. "The War Department Telegraph Code," says paragraph 5 of the instructions, "while not absolutely confidential, will be guarded with the greatest care and will never be out of the immediate possession or control of the officer to whom issued or of his confidential agent. Care will be taken to prevent theft, loss, use, or inspection except by those whose duties require them to employ the code. Special pains will be taken to prevent the code from falling into the hands of unauthorized persons or of the enemy."

This new code was intended, as was its predecessor, to serve two purposes: "First, secrecy, and second, economy. When secrecy is desired it is to be used as a cipher code, as is explained in subsequent paragraphs under 'Enciphered Code.'" But there are no subsequent paragraphs in which this is explained. Apparently some change in this regard was decided, because I have seen, as a separate pamphlet, a set of cipher tables for use with this code.

The code itself embodied some of the latest ideas of code compilation. It had over 113,000 code groups, and these were both 5-figure groups and, for the first time, 5-letter groups. The latter embodied the principle of the 2-letter difference, but the instructions do not mention this fact and no permutation table was included in the code itself. The book has a very extensive vocabulary of words, phrases, and sentences. Here is a picture of a typical page (Fig. 77). I feel sure that a great deal of thought and effort went into the production of this code, but I must tell you two things about it. First, I must tell you that my immediate predecessor in the Office of the Chief Signal Officer told me, on my return from France in 1919, that that particular edition of the *War Department Telegraph Code* had been printed in Cleveland by a commercial printer, and second, that when the United States became a belligerent in World War I

our British Allies found it desirable to notify the U.S. Government (through our G-2) that r *War Department Telegraph Code* was not safe to use, even with its superencipherment tables. ne implications of this notification are rather obvious and hardly require comment. The compilation of a new code in 1917 was initiated, but this time the work was done within and under the direction of the Military Intelligence Division of the General Staff (G-2), and in particular within the section devoted to cryptanalysis. This undertaking, which indubitably was a direct affront to the Signal Corps of the Army, met with no objection, it seems, from that group; perhaps it deserved the intended insult because of its longstanding neglect of its clear responsibilities for cryptography and cryptographic operations in and for the Army.

We have noted how inadequately the Army and the War Department were equipped for cryptocommunications in the years from 1885 to 1915. Let us see how well equipped the Navy and the Navy Department were. For this purpose I have an excellent example and one of great historical significance and interest. You will recall my mention of the appointment of a board of Navy officers to prepare a suitable cryptosystem for the Navy and I told you about the large *basic* vocabulary and tabular contents of the codebook and its accompanying two large books, one for enciphering the code groups, the other for geographical names. For the story we go back to the time of President McKinley, whose election brought Theodore Roosevelt, a former member of the Civil Service Commission, back to Washington as Assistant Secretary of the Navy. Teddy was an ardent advocate of military and naval preparedness. He forthrightly and frankly favored a strong foreign policy, backed by adequate military and naval strength—"speak softly but carry a big stick" was his now famous motto. He was looking forward, in fact, to forcing the ultimate withdrawal of the European powers from the Western Hemisphere. With vigor, he set to work to make the Navy ready. When the Battleship *Maine* was blown up in Havana harbor, on 15 February 1898, Roosevelt sharpened his efforts. During a temporary absence of his chief, Navy Secretary John D. Long, he took upon himself to initiate the preparations which he had in vain tried to persuade the Secretary to make. He ordered great quantities of coal and ammunition, directed the assembling of the

February 25, 1898.

Dewey, Hong Kong .

~~Secret and Confidential.~~

Order the Squadron except Monocacy to Hong Kong. Keep full of coal. In the event of declaration war Spain, your duty will be to see that the Spanish squadron does not leave the Asiatic coast and then offensive operations in Philipine Islands. Keep Olympia until further orders.

Roosevelt

Figure 78.

Fleet, and stirred the arsenals and navy yards into activity. On a miserably cold Saturday afternoon, ten days after the *Maine* was blown up, and still in the absence of Secretary Long, Teddy sat down and wrote out a cablegram to go to Commodore George Dewey, at Hong Kong. Here it is, with his bold signature at the bottom:

That is the now historic message which alerted Dewey and which resulted in our taking over, under U.S. protection in the war with Spain which was declared ten days later, the Philippine Islands.

You will note that the message bears on its face a security classification, but the classification, "Secret and Confidential," was crossed out. That must have been many years later, for those three words appear in the plain text of the deciphered and decoded cablegram. Here is a picture of the code cablegram with its strange and outlandish code words, as it was received in Hong Kong:

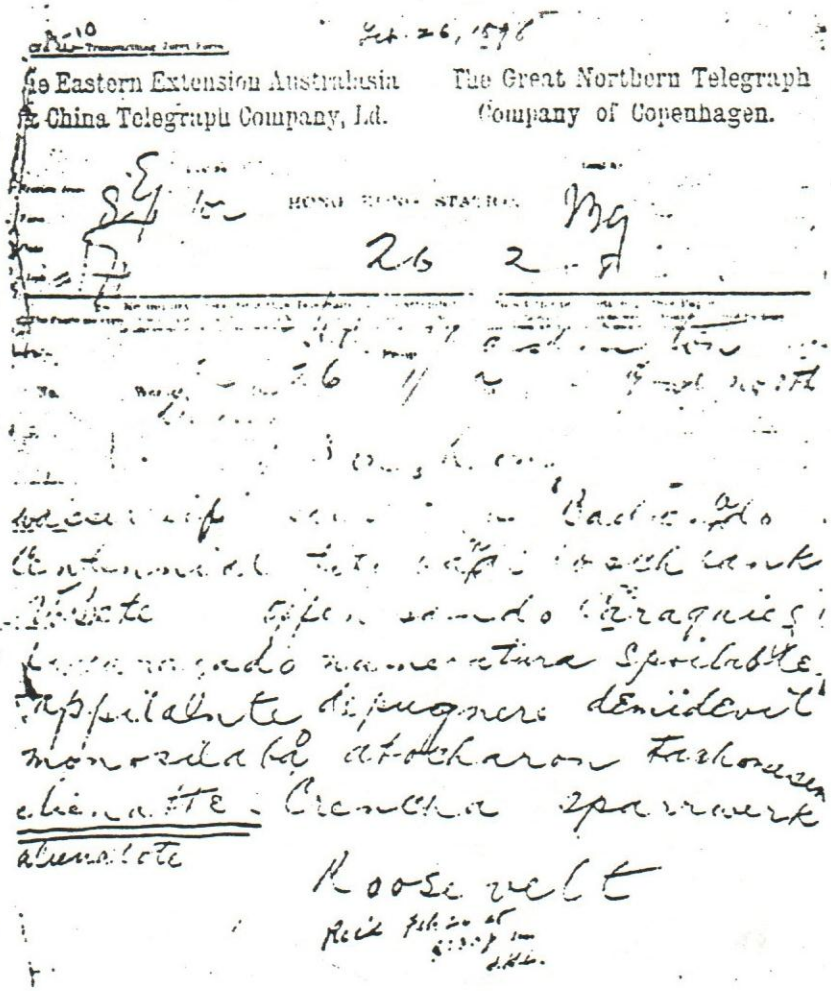


Figure 79.

And now I show you the deciphered and decoded text, which I was fortunate in being able

THEODORE ROOSEVELT, ASST. SECRETARY OF THE NAVY, TO ADMIRAL DEWEY, HONG KONG,
26 FEBRUARY 1898

1	1	2	3	4	5	6
2	WASSERREIF	PAUSATURA	BADANADOS	CENTENNIAL	TITYBANDI	LOSCHBANK
3	99055	62399	11005	16820	90000	52390
4		990.556	239.911	005.160	289.200	052.390
5		SECRET AND CONFIDENTIAL	ORDER THE SQUADRON	EXCEPT	THE MONOCACY	TO HONGKONG, CHINA

1	7	8	9	10	11	12
2	VOVETE	OFFENSADO	C(A)RAQUIEZ(a)	PICARAZADO	NUMERATURA	SPOILABLE
3	98242	59841	21992	64004	56639	03607
4		982.425	984.121	992.640	045.863	983.607
5		KEEP FULL OF COAL	IN THE EVENT OF	DECLARATION OF WAR	SPAIN	IT WILL BE YOUR DUTY TO SEE THAT

1	13	14	15	16	17	18
2	APPILANTI	DEPUGNERE	DEMIDEVIL	HONOSILABO	ATOCHARON	TACHONASEN
3	07319	25545	24930	56346	09599	07782
4		073.192	554.524	983.563	460.959	987.782
5		THE SPANISH SQUADRON	DOES NOT LEAVE	ASIATIC COAST	AND THEN	OFFENSIVE OPERATION(S)

1	19	20	21
2	ALIENATOTE(b)	CRENCRA	SPARRWERKE
3	24665	22099	51000
4		046.653	209.963	000
5		IN PHILIPPINE ISLANDS	KEEP OLYMPIA UNTIL FURTHER ORDERS

LEGEND: 1 - Group Number.
2 - Cable Word.
3 - Cable Word No.
4 - Code Number in Code.
5 - Meaning.

(a) Correction necessary: The "A" is to be omitted.

(b) Correction necessary: Group was received as ALIENATTE.

Figure 80.

translate a message in the code then in use three steps are necessary. First, the cable words (the peculiar, outlandish words in line 2—WASSERREIF, PAUSATURA, BADANADOS, etc.) are sought in the cipher book, and their accompanying cable-word numbers set down. WASSERREIF yields 99055; PAUSATURA yields 62399, BADANADOS, 11005, etc. The next step is to append the first digit of the second cable-word number to the last digit of the first cable-word number to make the latter a six-digit number. Thus 99055 becomes 990556. The six-digit code group number, 990556, is then sought in the basic code book and its meaning is found to be "Secret and Confidential." The transfer of the first digit, 6, of the second cable-word number, 62399, makes it become code-number 2399, to which must now be appended the first two digits of the third cable-word number, 11005, thus making the second code group of the code message 239911, which is sought in the basic code book and yields the meaning "Order the squadron." And so on. It's painfully slow work, and I haven't told you about some of the difficulties I encountered in the process, including having to refer to the third book, the *General Geographical Tables*. It took me at least an hour to decipher and decode this one relatively short Roosevelt

message. I feel sure a naval operation in World War II or in World War I, for that matter, could never have been executed before a message even as brief as the Roosevelt one could be deciphered and decoded by this cumbersome system, even if all the digits had been transmitted and received correctly. Generally speaking, naval battles are fierce and quickly over. For instance, on 4 June 1942, between 10:24 and 10:26 a.m., the war with Japan was decided when the U.S. Pacific Fleet under Admirals Nimitz, Fletcher and Spruance won the Battle of Midway, in which the Japanese lost four fast carriers, together with their entire complement of planes, and almost all their first-string aviators. When our Navy entered World War I a much more practical system was put into effect, using a cipher device known as the NCB, standing for "Navy Cipher Box," to encipher 5-letter groups of a basic code.

We come now to European events of importance in this cryptologic history. During the decades from the end of the Civil War in America to the first decade of the 20th Century, there was some progress in cryptologic science in Europe, but it was not of a startling nature. German Army Major Kasiski's demonstration of a straight forward, mathematical method of solving the Vigenère cipher was published in Berlin during the mid-period of the Civil War in America. If the book created an impression in Europe, it was altogether unspectacular; in America it remained unheard of until after the advent of the 20th Century. Although Kasiski's method is explained quite accurately in the first American text on cryptology,[2] the name Kasiski doesn't even appear in it. Other books on cryptologic subjects appeared in Europe during this period, and two of them deserve special attention. The first, by Commandant Bazeries, is a book notable not for its general contents, which are presented in a rather disorganized, illogical sequence, but for its presentation of a cipher device invented by the author, the so-called "cylindrical cipher device." But our own Thomas Jefferson anticipated Bazeries by a century, and the manuscript describing his "Wheel Cypher" is among the Jefferson Papers in the Library of Congress. The second book which deserves special attention is one by another French cryptologist, the Marquis de Viaris, in which he presents methods for solving cryptograms prepared by the Bazeries cipher cylinder, and although unknown to him, the ciphers of Jefferson's Wheel Cypher.[3]

It was in the period during which books of the foregoing nature were written and published that the chanceries of European Governments operated so-called "Black Chambers," organized for solving one another's secret communications. Intercept was unnecessary because the governments owned and operated the telegraph systems, and traffic could be obtained simply by making copies of messages arriving or departing from telegraph offices or passing in transit through them. This was true in the case of every country in Europe with one very important exception: Great Britain. The story, which is given in detail in a recently published and very fully documented book,[4] is highly interesting but I must condense it to a few sentences.

In England, from about the year 1540 onward until 1844, there was a "black chamber" in constant operation. It was composed of three collaborating organizations within the Post Office respectively called "The Secret Office," the Private Office," and "The Deciphering Branch."

In the first of these carefully hidden secret organizations, letters were opened, copies of them were made, the letters replaced, the envelopes resealed, and if the wax seals were intact they were merely replaced. If the seals were not replaceable, duplicates were forged and affixed to the envelopes. Copies of letters in cipher were sent to the "Deciphering Branch"

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[2]Capt. Parker Hitt's *Manual for the Solution of Military Ciphers*, Fort Leavenworth, Kansas: Army Service Schools Press, 1916.

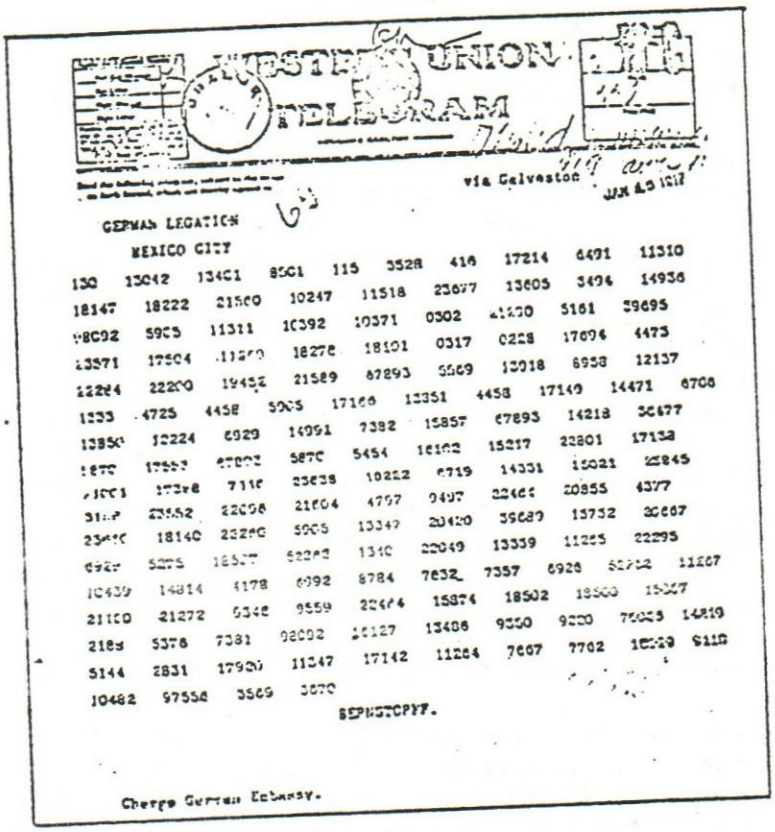
[3]L'art de chiffrer et déchiffrer les dépêches secrètes, Paris, 1893.

[4]Ellis, Kenneth L. *The Post Office in The Eighteenth Century: A Study in Administrative History*. London: Oxford University Press, 1958, pp. 176. In conjunction with this book one should by all means also read the following extremely interesting and revealing article by the same author: "British Communications and Diplomacy in the Eighteenth Century," *Bulletin of the Institute of Historical Research*, Vol. XXXI, No. 84, Nov 1958, pp. 159–167.

for solution and the results, if successful, were then sent to the Foreign Office. A famous mathematician, John Wallis, took part in the latter activities. The "Private Office" took care of similar activities but only in connection with internal or domestic communications. In 1844, a scandal involving these secret offices caused Parliament to close them down completely, so that from 1844 until 1914 *there was no black chamber at all in Britain.* As a consequence, when World War I broke out on the first of August 1914, England's black chamber had to start from scratch. But within a few months British brains and ingenuity built a cryptologic organization known as "Room 40 O.B.", which contributed very greatly to the Allied victory in 1918. Although the British Government has never issued a single official publication on the activities and accomplishments of "Room 40 O.B.," several books by private authors have pushed aside the curtain of secrecy to make a most fascinating story too long to tell in this lecture. But I must tell you at least something about what was perhaps the single greatest achievement of "Room 40 O.B.," an achievement which just in the nick of time brought this country into World War I as an active belligerent on the Allied side and saved England from possible destruction. as well as France. The operation involved the interception and solution of a message known as the Zimmermann Telegram, deservedly called the most important single cryptogram in all history. On 8 September 1958 I gave before an NSA audience a detailed account of this amazing cryptogram. I told about its interception and solution: I told how the solution was handed over to the United States; how it brought America into the war on the British side; and how all this was done without disclosing to the Germans that the plain text of the Zimmermann Telegram had been obtained by interception and solution by cryptanalysis, that is, by science and not by treason. My talk was given under the auspices of was recorded, and is on file so that, if you wish, you can hear it. It took two and a half hours to deliver and at that I didn't quite succeed in telling the whole story. But you may read an excellent account of this episode, set forth in great detail in a book entitled *The Zimmermann Telegram*, by Barbara Tuchman, published in 1958 by the Viking Press, New York. Also, you should consult a book entitled *The Eyes of the Navy*, by Admiral Sir William James, published in 1955 by Methuen & Co., London. Both books deal at length with *The Zimmermann Telegram* and tell how astutely Sir William Reginald Hall, Director of British Naval Intelligence in World War I, managed the affair so as to get the maximum possible advantage from the feat accomplished by "Room 40 O.B." It was, indeed, astounding! To summarize, as I must, this fascinating and true tale of a very important cryptanalytic conquest, let me show you again the telegram as it passed from Washington to Mexico City, for if you will remember, I showed it to you in the very first lecture of this series, and promised to tell you about it later. Here I show it to you once again. As you can easily see, the code groups are composed of three, four, and five-digit groups, mostly the latter. Here is the English decoded translation of the message as transmitted by our Ambassador Page in London to President Wilson:

> 'Foreign Office Telegraphs Jan. 16, No. 1. Most secret. Decipher yourself.
> 'We intend to begin unrestricted submarine warfare on the first of February. We shall endeavour in spite of this to keep the United States of America neutral. In the event of this not succeeding, we make Mexico a proposal of alliance on the following basis. Make war together, make peace together, generous financial support and an understanding on our part that Mexico is to reconquer the lost territory in Texas, New Mexico and Arizona. The settlement in detail is left to you. You will inform the President (of Mexico) of the above most secretly as soon as the outbreak of war with the United States of America is certain, and add the suggestion that he should, on his own initiative, invite Japan to immediate adherence, and at the same time mediate between Japan and ourselves. Please call the President's attention to the fact that the ruthless employment of our submarines now offers the prospect of compelling England, in a few months, to make peace.
>
> 'ZIMMERMANN.'

From the day that Ambassador Page sent his cablegram to President Wilson, on 28 February 1917, quoting the English translation of the Zimmermann Telegram in the form in which it had been forwarded by German Ambassador von Bernstorff in Washington to German Minister



UNION TELEGRAM

via Galveston

JUN 25 1917

GERMAN LEGATION

MEXICO CITY

130 13042 13401 8501 115 3528 416 17214 6491 11310
18147 18222 21500 10247 11518 23677 13605 3496 14936
W8092 5905 11311 10392 10371 0302 21470 5161 29695
13571 17504 11370 18276 18101 0317 0228 17694 4473
12284 22200 19452 21589 87893 5569 12018 6958 12137
1233 4725 4458 5905 17166 12351 4458 17149 14471 6706
13850 12224 6929 14091 7382 15857 67893 14218 36477
1870 17552 67802 5870 5454 16102 15217 22801 17138
21001 17348 7110 23638 18222 6719 14331 15021 65845
31?? 23552 22098 21604 4797 9497 22466 20855 4377
23??? 18140 22270 5905 13347 20420 39689 15732 30667
6?47 5275 18507 52268 1310 22049 13339 11225 22295
10439 14814 4178 6092 8784 7652 7357 6926 52?52 11267
21100 21272 6348 9559 22474 15874 18502 18500 15027
218? 5378 7381 92092 20127 13406 9350 9220 75025 14819
5144 2831 17920 11047 17142 11264 7607 7702 16?29 6116
10482 97556 3509 3070

SEPHSTOPFF.

Chargé German Embassy.

Figure 81.

von Eckhardt in Mexico City, the entrance of the United States into the war as a belligerent on the side of the Allies became a certainty. Under big black headlines the English text appeared in our newspapers, because, after assuring himself of the authenticity of the telegram handed over by the British and that it had been decoded and checked by a member of Ambassador Page's own staff, President Wilson directed that the text of the message be released to the Associated Press. Its publication the next day was the first of a momentous and sensational series of reports and accounts of the Zimmermann Telegram and its contents.

There were plenty of members of Congress who disbelieved the story. But when Zimmermann himself foolishly acknowledged that he had indeed sent such a telegram, disbelief changed quickly into most vehement anger. Thus, it came about that Americans in the Middle West and Far West, who had thus far been quite unconcerned about a War that was going on in Europe, thousands of miles away, and wanted no part of it, suddenly awoke when they learned that a foreign power was making a deal to turn over some rather large slices of U.S. real estate to a then hostile neighbor across the southern border. They were aroused to the point where they, too, as well as millions of other Americans in the East, were ready to fight. Surely war would now be declared on Germany.

Notwithstanding all the furor that the disclosure of the Zimmermann Telegram created in America, President Wilson still hesitated. He was still determined that America would not, must not, fight. It was not until more than a month later, *and after several American ships were sunk without warning on 18 March*, that a now fully aroused President got Congress to declare war on Germany and her allies. The date was 6 April 1917.

In the War Department and in the Navy Department the pace set for preparing for active war operations quickened. It is difficult to believe, but I assure you that it was true, that

there was at the moment in neither of those departments, nor in the Army or Navy, any organizations or technical groups whatever, either for intercepting enemy communications or for studying them, let alone solving such communications. There was, it is true, since the autumn of 1916, a very small group of self-trained cryptanalysts, sponsored and supported by a private citizen named Colonel George Fabyan,[5] who operated the Riverbank Laboratories at Geneva, Illinois. I served as leader of the group, in addition to other duties as a geneticist of the Laboratories. Riverbank, through Colonel Fabyan, had initiated and established an unofficial or, at most, a quasi-official relationship with the authorities in Washington, so that it received from time to time copies of cryptographic messages obtained by various and entirely surreptitious means from telegraph and cable offices in Washington and elsewhere in the U.S. At that period in our history diplomatic relations with Mexico were in a sad state, so that U.S. attention was directed southward, and not eastward across the Atlantic Ocean. Therefore, practically all the messages sent to Riverbank for solution were those of the Mexican Government. Riverbank was successful in solving all or nearly all the Mexican cryptograms it was given, usually returning the solutions to Washington very promptly. The great majority of them were of the Vigenère type but using mixed sequences with relatively long key phrases. Riverbank was also successful with certain other cryptograms which were concerned with the war in Europe, but I cannot deal with them now because there just isn't time. Soon after the U.S. declared war on Germany, Colonel Fabyan established a school for training at Riverbank, and he invited the Services to send him Army and Navy officers to learn something about cryptology in formal courses established for the purpose. Each course lasted about six weeks, full time.

You may like to know what we novices used for training ourselves for this unusual task and what we used later on for training the student officers sent to us for cryptologic instruction. As regards our self-instruction training material, there wasn't much available in English, but among the very sparse literature there was that small book by Captain Parker Hitt, called *Manual for the Solution of Military Ciphers*, to which I referred earlier. Colonel Fabyan managed to get a copy of that *Manual* for us to study. The Signal Corps School was then one of the Army Service Schools, and there a few lectures were given by two or three officers who, when World War I broke out in August 1914, took an interest in the subject of military cryptography. They foresaw that sooner or later there would be a need for knowledge in that important branch of military technology. Capt. Hitt's *Manual* was then, and still is, a model of compactness and practicality. Let me show you the title page of the first edition (Fig. 82).

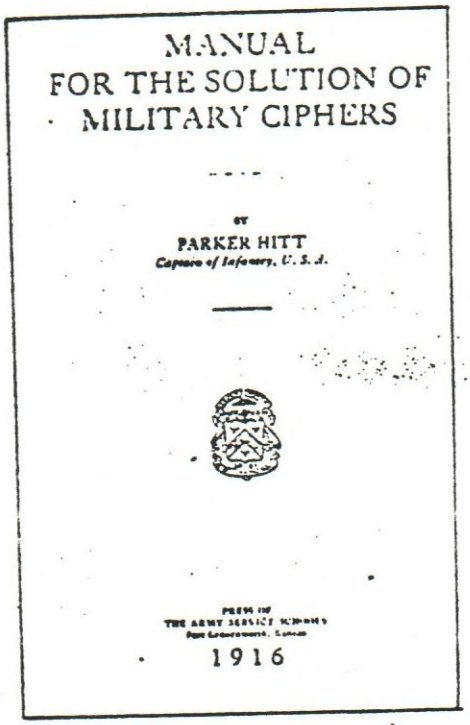
It was the succinctness of Parker Hitt's *Manual* that caused us much work and perspiration in our self-training at Riverbank, but we later came to know and admire its author, whose photograph I now show you as he looked when he became a Colonel in the Signal Corps (Fig. 83).

There was one other item of training literature which we also studied avidly. It was a very small pamphlet entitled *An Advanced Problem in Cryptography and its Solution*, and it too was put out by the Fort Leavenworth Press in 1914. Here is its title page (Fig. 84). You will note that its author was then 1st Lieut. J. O. Mauborgne; he advanced to become a Major General and Chief Signal Officer of the Army (Fig. 85). The "advanced problem" dealt with in that pamphlet was the Playfair Cipher, about which I shall say only that at the time Mauborgne wrote about that particular cipher it was considered to be much more difficult than it is at present.

Returning now to what Riverbank's self-trained cryptanalytic group was able to do in a practical way in the training of others, there exist in NSA archives copies of the many exercises and problems prepared at Riverbank for this purpose. They are, I think, still of much interest as curiosities of U.S. cryptologic history.

In Lecture II, I showed you a picture of the last of the several classes sent by the Army to Riverbank for training. It should be noted, and it gives me considerable pleasure to tell you,

[5]Honorary title conferred by the Governor of Illinois for Fabyan's participation as a member of the Peace ommission that negotiated the Treaty of Portsmouth, which terminated the Russo-Japanese War in 1905.


MANUAL
FOR THE SOLUTION OF
MILITARY CIPHERS

BY
PARKER HITT
Captain of Infantry, U. S. A.

PRESS OF
THE ARMY SERVICE SCHOOLS
Fort Leavenworth, Kansas
1916

Figure 82.

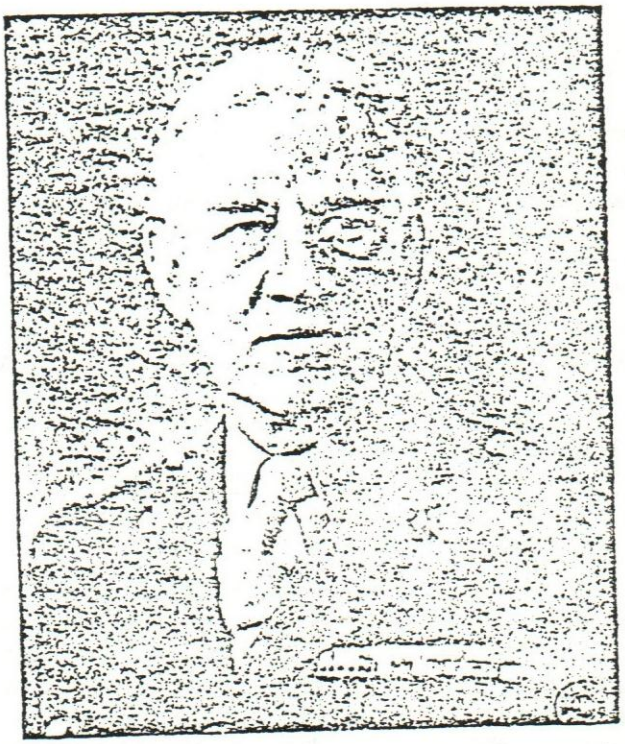
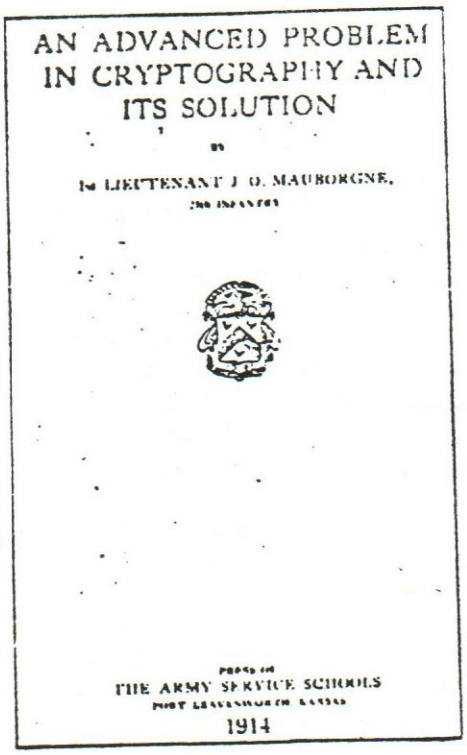


Figure 83.


AN ADVANCED PROBLEM
IN CRYPTOGRAPHY AND
ITS SOLUTION

BY

1st LIEUTENANT J. O. MAUBORGNE,
2ND INFANTRY

PRESS OF
THE ARMY SERVICE SCHOOLS
FORT LEAVENWORTH, KANSAS
1914

Figure 84.

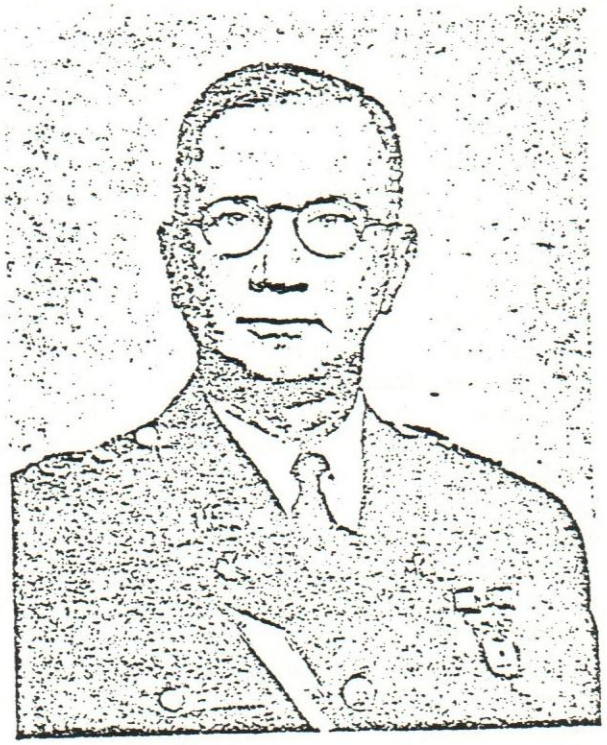


Figure 85.

hat this instruction was conducted at Colonel Fabyan's own expense as his patriotic contribution to the U. S. war effort. I can't, in this lecture, say much more about this than that it involved the expenditure of many thousands of dollars, never repaid by the government—not even by income-tax deduction or by some decoration or similar sort of recognition. Upon completion of the last training course, I was commissioned a First Lieutenant in Military Intelligence, General Staff, and ordered immediately to proceed to American General Headquarters in France, where I became a member of a group officially referred to as the Radio Intelligence Section. But it was the German Code and Cipher Solving Section of the General Staff, a designation that was abbreviated as G–2, A–6, GHQ–AEF. As the expanded designation implies, the operations were conducted in two principal sections, one devoted to working on German Army field ciphers, the other, to working on German Army field codes. There were also very small groups working on other material such as meteorologic messages, direction-finding bearings, and what we now call traffic analysis, that is, the detailed study of "the externals" of enemy messages in order to determine enemy order of battle and other vital intelligence from the study of D/F bearings, the direction, ebb and flow of enemy traffic, and other data sent back from our intercept and radio direction-finding operations at or near the front line in the combat zone.

In connection with the last-mentioned operations you will no doubt be interested to see what is probably one of the earliest, if not the very first, chart in cryptologic history that shows the intelligence that could be derived from a consideration of the results of traffic analysis. Its utility in deriving intelligence about enemy intentions from a mere study of the ebb and flow of enemy traffic, without being able to solve the traffic, was of unquestionable value. Here's that historic chart (Fig. 86), which I must tell you was drawn up from data based solely upon the ebb and flow of traffic in what we called the ADFGVX cipher,[6] a clever cryptosystem which was devised by German cryptographers and which was restricted in its usage to German High Command communications, principally those between and among the headquarters of divisions and army corps. Its restriction to such high command messages made a study of its ebb and flow very important. Theoretically, that cipher was extremely secure. It combined both a good substitution and an excellent transposition principle in one system without being too complicated for cipher clerks. Below is a diagram which will give a clear understanding of its method of usage. If you wish further details I suggest you consult documents available in the Cryptanalytic Literature Staff of the NSA Office of Training Services. In this lecture there is only time to tell you that although individual or isolated messages in the ADFGVX system then appeared to be absolutely impregnable against solution, a great many messages transmitted in it were read by the Allies. You may be astonished by the foregoing statement and therefore may desire some enlightenment here and now on this point. In brief, there were in those days three and only three different methods of attacking that cipher. Under the first method it was necessary to find, as the first step, two or more messages with identical plaintext beginnings because they could be used to uncover the transposition, which was the second step. Once this had been done, the cryptanalyst had then to deal with a substitution cipher in which two-letter combinations of the letters A, D, F, G, V, and X represented single plaintext letters. The messages were usually of sufficient length for this purpose. Under the second method, two or more messages with identical plaintext endings could be used to uncover the transposition. This was easier even than in the case of messages with identical beginnings. You might think that cases of messages with identical beginnings or endings would be rather rare, but the addiction to stereotypic phraseology was so prevalent in all German military communications that there were almost invariably found, in each day's traffic, messages with similar beginnings or endings, and sometimes both. Under the third method of solution it was necessary to find several messages with exactly the same number of letters. This happened, but not often. This system first came into use on 1 March 1918,

[6] Initially this cipher employed only the letters A, D, F, G, and X, for a matrix of 5 × 5; later, the letter V was added, for a matrix of 6 × 6, for the 26 letters of the alphabet plus the ten digits.

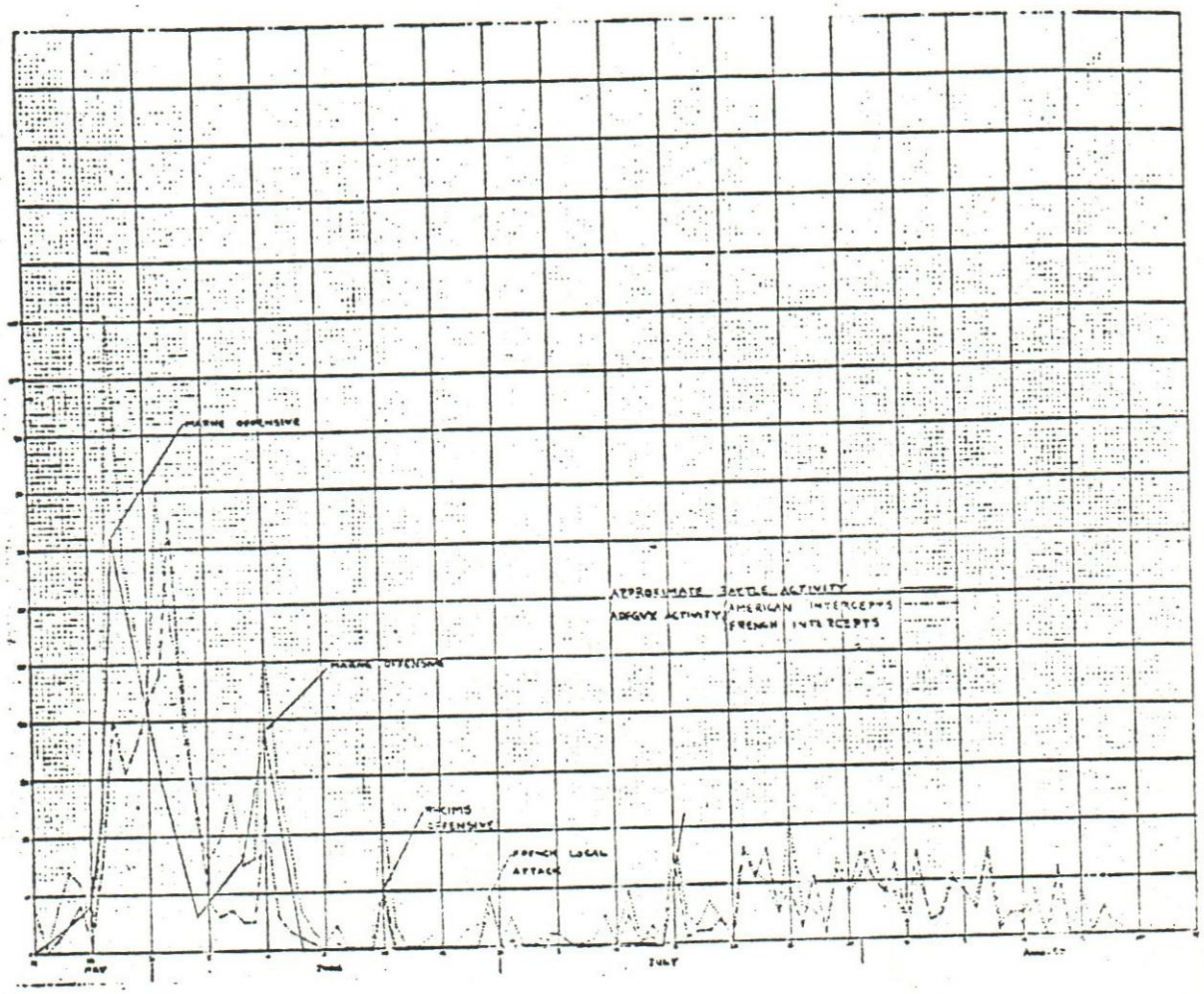


Figure 86.

three weeks before the last and greatest offensive by the German Army. Its appearance was coincident with that of other new codes and ciphers. The number of messages in the ADFGVX cipher varied from about 25 a day, when the system first went into use, to as many as about 150 a day at the end of two months. It took about a month to figure out a method of solution, and this was first done by a very able cryptanalyst named Capt. Georges Painvin of the French Army's Cipher Bureau.

The ADFGVX cipher was used quite extensively on the Western Front with daily changing keys during May and June of 1918, but then, for reasons somewhat obscure, the number of messages dropped very considerably. How many different keys were solved by the Allies during the four months from 1 March to the end of June? Not many—10 in all; that is, the keys for only 10 different days were solved. Yet, because the traffic on those days was very heavy, about 50% of all messages ever sent in that cipher, from its inception to its discard, were read, and a great deal of valuable intelligence was derived from them. On one occasion solution was so rapid that an important German operation disclosed by one message was completely frustrated.

Although the ADFGVX [illegible]me into use first on the Western Front, it later began to be employed also on the E[illegible]ont, with keys that were first changed every two days but

Plain text: REQUEST REI EMENTS IMMEDIATELY

Enciphering Square:

First letter \ Second letter	A	D	F	G	V	X
A	Q	U	E	5	S	T
D	I	9	0	N	A	1
F	B	2	L	Y	C	3
G	D	4	F	6	G	7
V	H	8	J	Ø	K	M
X	P	R	V	W	X	Z

Biliteral Substitution:

R	E	Q	U	E	S	T	R	E	E	N	F	O	R	C	E
XD	AF	AA	AD	AF	AV	AX	XD	AF	AF	DG	GF	DF	XD	FV	AF
M	E	N	T	S	I	M	M	E	D	I	A	T	E	L	Y
VX	AF	DG	AX	AV	DA	VX	VX	AF	GA	DA	DV	AX	AF	FF	FG

Key Word:

Q	U	I	C	K	B	R	O	W	N	F	O	X	J	U	M	P	E	D
14	16	6	2	8	1	15	11	18	10	5	12	19	7	17	9	13	4	3

Substituted Text:

X	D	A	F	A	A	A	D	A	F	A	V	A	X	X	D	A	F	A
F	D	G	G	F	D	F	X	D	F	V	A	F	V	X	A	F	D	G
A	X	A	V	D	A	V	X	V	X	A	F	G	A	D	A	D	V	A
X	A	F	F	F	F	G												

Transposed Text: ADAFF GVFAG AFDVA VAAGA FXVAA FDFDA AFFXD XXVAF AFDXF AXAFV GDDXA XXDAD VAFG

later every three days. On 2 November 1918 the key for that and the next day was solved within a period of an hour-and-a-half because two messages with identical endings were found. A 13-part message in that key gave the complete plan of the German retreat from Roumania.

During the 8 months of the life of the ADFGVX cipher, solution depended upon the three rather *special* cases I mentioned. No *general* solution for it was thought up by the Allies despite a great deal of study. However, members of our own Signal Intelligence Service, in 1933, devised a *general* solution and proved its efficacy. Pride in this achievement was not diminished when, in the course of writing up and describing the method, I happened to find a similar one in a book by French General Givierge (*Cours de Cryptographie*, published in 1925). Givierge was by then the head of the French Black Chamber which was called the "Deuxième Bureau," corresponding to our "G–2."

TABLE—I.—THE ALPHABETS FOR THE "WILHELM" CIPHER

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

Numbers were expressed by the following letters bracketed between "Q's":

1	2	3	4	5	6	7	8	9	0
H	F	J	W	D	Y	V	R	A	F

The alphabet beginning "SQRYV" was known as the "A" alphabet, that beginning "LOPNM" as the "B" alphabet, etc.

Messages numbered 1, 31, 61, etc., were decipherable by the 13 alphabets in the order "JVCEPQHCKPQGP".

Messages numbered 2, 32, 62, etc., were decipherable by the 13 alphabets in the order "TBUULENFKEQGG".

The horizontal sequence above the table is the plain-text sequence. The vertical alphabet on the extreme left gives the arbitrary symbol by which the different alphabets were known in the 30 keys. Attached is a list of these 30 keys:

Figure 87.

The ADFGVX cipher was not the only one used by the German Army in World War I, but there will be time to mention very briefly only two others. The first of these was a polyalphabetic substitution cipher called the "Wilhelm," which used a cipher square with disarranged alphabets and with a set of 30 fairly lengthy key words. The cipher square is shown in Fig. 87. Just why the square contains only 22 rows instead of 26 is probably connected with the fact that German can get along very well with fewer than 26 letters. Certainly the rows within the square are not random sequences, as you can see, for the letters within them manifest permuted arrangements in sets of five letters. In Fig. 88 is shown the keys used—30 of them. The key sequences seem to be composed of random letters but underlying them is plain text. I leave it to you to try to reconstruct the square, if possible. You should be able to reconstruct the real keys, for the latter problem should be relatively easy.

1.... J V C E P Q H C M P P G P
2.... T B U U L E N F K E Q G J
3.... V C B H E G C J K G E P
4.... I O C E B P G K K G P J V E G U G C
5.... H G J K E I I M P Q J B C K
6.... S O F C K M P K G C H C G N F M P Q
7.... L O Q G P L G N F J G U
8.... L B U U G P J E G S O F C G P
9.... P B N F G K L O J I E U N F
10.... G J J N F I G N A K I E C
11.... A B C A D E G F G C
12.... D M N A G C D O P Q G
13.... J N F L E G Q G C T O K G C
14.... L E G U O P Q G R O M G C K G J
15.... L E G T E G U A B J K G K G J
16.... S C G I R G P H M N F
17.... H G P G R E A K E P G C
18.... J G U K G C L O J J G C
19.... H G E L G I A O M S G P J E G
20.... V O V E G C F O P R U M P Q
21.... V S G C R G T G C I E G K G C
22.... Q B U R O C H G E K G C
23.... F O P R U M P Q J Q G F E U S G
24.... F O P R J N F M F I O N F G C
25.... E P J K C M I G P K G P I O N F G C
26.... A O I G U K C G E H G C
27.... C O R E G C Q M I I E
28.... H G J B C Q G R E G V S G C R G
29.... R M P A G U A O I I G C
30.... C G N F K J O G U G F C K G C

It will be noticed that the same letter, as P, for instance, in key no. 1, is repeated four different times. Again, the E and Q and G which occur in 1 occur also in 2. These facts pointed to the use in these 30 keys of intelligible German words. The arbitrary letters, which the keys in their present form contained, represented a simple substitution. This appeared from the frequency, for example, of G and the inseparable combinations KF and NA, N never appearing unless followed by F or A. It was therefore extremely probable that these letters, arbitrarily chosen to represent the 22 different alphabets, in reality represented keywords in German text.

N was assumed to be the value of C, and F, H; and G, the most frequent letter which was never absent from any of the series, E. This simple substitution was continued until familiar German syllables began to appear and finally the complete keywords themselves.

Figure 88.

The other German Army cipher to be mentioned is the double transposition, an example of which is shown below. The process consists in applying the same transposition key twice to the same matrix, once horizontally and once vertically, as seen in this slide. Solution of the true double transposition usually depends upon finding two or more messages of identical length. (You will remember what I told you about Capt. Holden in this connection.) No general solution was known to the Allies during World War I, and messages of identical length were few indeed. But it happened that occasionally a German operator would apply only the

	First transposition	Second transposition	Final cryptogram
Literal key:	B U R E A U		
Derived numerical key:	2 5 4 3 1 6	2 5 4 3 1 6	
	A T T A C K	C P N U A P	
	P O S T P O	N I A A T U	ATFKC NOOTU ADMNA SLPIT
	N E D U N T	O T S D F T	ERPUT O
	I L F O U R	O E L M K O	
	A M	T R	

first transposition, and when this fortunate situation occurred solution was easy, because the key thus recovered from the single transposition could be used to decipher other messages which had been correctly enciphered by the double transposition. Again, the Signal Intelligence Service devised a general solution for the double transposition cipher, and during World War II we were able to prove that such ciphers could be solved without having to find two messages of identical length. I think the devising of a general solution for the true double transposition cipher represents a real landmark of progress in cryptanalysis.

We come now to the code systems used by the belligerents in World War I. And first, let us differentiate those used for diplomatic communications from those used for military communications. What sorts did the German Foreign Office use? We have noted that the British Black Chamber, "Room 40 O.B.," enjoyed astonishing success with the code used for the transmission of the Zimmermann Telegram. Excessive pride in German achievements in science, a wholly unjustified confidence in their communication cryptosecurity, and a disdain for the prowess of enemy cryptanalysts laid German diplomatic communications open to solution by the Allies to the point where there came a time when nothing the German Foreign Office was telling its representatives abroad by telegraph, cable or radio remained secret from their cryptologic antagonists. For those of you who would like to learn some details, I refer you to the following monograph on the subject by my late colleague, Captain Charles J. Mendelsohn: *Studies in German Diplomatic Codes Employed During the World War*, Government Printing Office, 1937. Copies of it are available in the Office of Training Services. Says Dr. Mendelsohn:

> . . "At the time of America's entrance into the war German Codes were an unexplored field in the United States. About a year later we received from the British a copy of a partial reconstruction of the German Code 13040 (about half of the vocabulary of 19,200 words and 800 of the possibly 7,600 proper names). This code and its variations of encipherment had been in use between the German Foreign Office and the German Embassy in Washington up to the time of the rupture in relations, and our files contained a considerable number of messages, some of them of historical interest, which were now read with the aid of the code book."

The vocabulary of the German diplomatic codes comprised about 189, pages each having 100 words or expressions to the page, arranged in two columns of 50 each, accompanied by numbers from 00 to 99. In each column the groups were in blocks of 10. In the left-hand column, for instance, were the five blocks from 00–09, 10–19, etc., to 40–49. Then 50–59, 60–69, etc., were in blocks of 10 in the right-hand column. The pages in the basic code were numbered, and from this code several codes were made by the use of conversion tables. This enabled the original or basic code to serve as the framework for apparently unrelated and externally distinguishable codes for several different communication nets. What the number of the basic code was is unknown, but we do know that from the code designated as Code 13040 came codes 5950, 26040, and others, derived merely by means of tables for converting the page numbers in the basic code into different page numbers in the derived code. These conversions were systematic, in blocks of fours. Thus, for example, pages 15–18 in code 13040 became pages 65–68 in code 5950, etc. Then there were tables for converting line numbers from one code into different line numbers in another version of the basic code, and this was done in blocks of 10. For example, the fifth block (penultimate figure 4) became the first (penultimate figure 0), and the 1st, 2d, 3d, and 4th blocks were moved down one place. The other five blocks (on the right-hand side of the page) were rearranged in the same manner.

It is obvious that codes derived in such a manner from a basic code by renumbering pages and shifting about the contents of pages in blocks can by no means be considered as being different and entirely unrelated codes, and once a relationship between two such codes was discovered, the two could be handled as equivalents of one another. Also to be mentioned is the fact that in certain cases numbers were added to or subtracted from the code numbers of a message, and this gave rise to what seemed to be still different codes. It was not difficult to determine the additive or subtractive and thus get to the basic code numbers.

In none of the cases of codes mentioned thus far was there one that could be considered to be a randomized, "hatted," or true two-part code, since the same book served for both encoding and decoding. However, the German Foreign Office later on did compile and use real two-part, truly randomized codes of 10,000 groups numbered from 0000 to 9999. One such code had as its indicator the number 7500. And that there were several others like it I have no doubt.

When one reviews Dr. Mendelsohn's monograph, one becomes overwhelmed by the multiplicity of the codes and variants threof used by the German Foreign Office. Some were basic

codes, but many were derivatives or superencipherments thereof. It is even hard to ascertain the exact number of different codes and superencipherment methods. Yet a great deal of the traffic in these codes was read. Considering the rather small number of persons on the cryptanalytic staff of G-2 in Washington and in the British counterpart organization in London, the British Black Chamber, one can only be astonished by the remarkably great achievements of these two collaborating organizations that worked on German diplomatic codes during World War I.

So much for German diplomatic secret communications. What about German military cryptocommunications? I have already mentioned several of the systems used, but these were developed two or more years after the outbreak of World War I. When World War I commenced, the German Army was very poorly prepared to meet the requirements for secure communications. It seems that up until the Battle of the Marne in 1914 several Army radio stations went into the field without any provision having been made, or even foreseen, for the need for speedy and secure cryptocommunications. Numerous complaints were registered by German commanders concerning extensive loss of time occasioned by the far too complicated methods officially authorized for use and the consequent necessity for sending messages in the clear. Not only did this reveal intelligence of importance to their opponents, but, what is equally important, the practice permitted the British and the French to become thoroughly familiar with the German telegraphic procedures, methods of expression, terminology and style, and the knowledge gained about these items became of great importance in cryptanalysis when German cryptosystems improved. The German Army learned by hard experience something about its shortcomings in this area of warfare and not only soon began to improve but it did so to the point where we must credit the Germans with being the initiators of new and important developments in field military cryptography. In fact, the developments and improvements began not long after the Battle of the Marne and continued steadily until the end of the war. When on 11 November 1918 the armistice ended active operations, German military cryptography had attained a remarkably high state of efficiency. The astonishing fact, however, is that, although very proficient in cryptographic inventions, they were apparently quite deficient in the science and practice of cryptanalysis. In all the years since the end of World War I no books or articles telling of German success with Allied radio traffic during that war have appeared; one Austrian cryptanalyst, a man named Figl, attempted to publish a book on cryptanalysis, but it seems to have been suppressed. One could, of course, assume that they kept their successes very well hidden, but the German archives taken at the end of World War II contained nothing significant in regard to cryptanalysis during World War I, although a great deal of important information in this field during World War II was found. A detailed account of the cryptologic war between the Allied and German forces in World War II would require scores of volumes, but there is one source of information which I can highly recommend to those of you who would like to know more details of the cryptologic warfare between the belligerents in World War I. That source is a book written and published in Stockholm in 1931 by a Swedish cryptanalyst, Yves Gyldén, under the title *Chifferbyråernas Insatser I Världskriget Till Lands*, a translation of which, with some comments of my own in the form of footnotes, you will find on file in the Office of Training Services under the title *The Contribution of the Cryptographic Bureaus in the World War*, Government Printing Office, 1936.

In this lecture, however, we are principally concerned with German military cryptography during World War I, and since I have already told you something about the cipher systems that were used, there remain to be discussed the field codes. It was the German Army which first proved that the old idea that codebooks were impractical for use in the combat zone for tactical communications was wrong. They had two types of field codes: one which they called the SCHLUESSELHEFT but which we called the "three-number code," the other which they called the SATZBUCH but which we called the "three-letter code". The former was a small, standardized code with a vocabulary of exactly 1,000 frequently used words and expressions, digits, letters and syllables, etc., for which the code equivalents were 3-digit num-

bers. A cipher was applied only to the first two digits of the code numbers and this cipher consisted of 2-digit groups taken from a 10 x 10 matrix for enciphering the numbers from 00 to 99. This table was called the GEHEIMKLAPPE or "Secret Key," and here's a picture of one (Fig. 89). The last digit of a code group remained unenciphered. Thus, code group 479 would become 629. Each division compiled and issued its own secret key table, which was in two parts, or sections, of course, one for encipherment, the other for decipherment. The three-number code was intended for use in all forms of communication within, or to and from, a 3-kilometer front-line danger zone. Although this code was completed by the end of January 1918, it was not distributed or put into use until the opening day of the last and greatest German offensive, 10 March 1918. Our code-solving section, through good fortune and careful attention, ascertained the nature of the new code, and a few groups in it were solved the very same day the code was put into effect, because a German cipher operator who was unable to translate a message in the new code requested and received a repetition in another code

Verschlüsselungstafel.

	0	1	2	3	4	5	6	7	8	9
0	23	48	60	05	78	35	58	64	29	52
1	20	77	33	59	21	70	02	40	63	08
2	11	49	01	69	47	41	79	74	22	42
3	32	76	39	18	75	30	09	51	80	65
4	61	19	43	81	06	56	73	62	10	28
5	85	50	24	88	31	84	27	90	55	57
6	03	91	96	53	68	16	44	89	15	87
7	97	25	71	04	95	34	14	37	93	38
8	26	72	54	92	13	83	45	00	66	07
9	86	12	98	36	99	46	82	17	94	07

Entschlüsselungstafel.

	0	1	2	3	4	5	6	7	8	9
0	87	22	16	60	73	03	44	99	13	36
1	42	20	51	34	76	68	05	97	33	41
2	10	14	28	00	52	71	80	55	49	08
3	35	54	30	12	75	05	93	77	79	32
4	17	25	29	42	66	86	95	24	01	21
5	51	37	09	63	82	58	45	59	06	13
6	02	40	47	18	07	39	88	89	64	23
7	15	72	81	46	27	34	31	11	04	26
8	38	43	96	85	55	50	90	69	53	67
9	57	61	83	78	98	74	62	70	92	94

Figure 89.

which had been solved to an extent which made it possible to identify homologous code groups in both messages. The three-number code proved rather easy to solve on a daily basis because only the encipher-decipher table was changed. Much useful intelligence was obtained from the daily solution of this key.

The solution of the SATZBUCH, or three-letter code, however, proved to be a much more difficult problem. In the first place, it had a much larger vocabulary, with nulls and many variants for frequently used words, letters, syllables and numbers; in the second place, and what constituted the real stumbling block to solution, was the fact that it was a true two-part randomized or "hatted" code; and in the third place, each sector of the front used a different edition of the code, so that traffic not only had to be identified as to the sector to which it belonged but also it was not possible to combine all the messages for the purpose of building up frequencies of usage of code groups. Here is a typical page of one of these codes (Fig. 91). Working with the sparse amount of traffic within a quiet sector of the front and trying to solve a few messages in this code was really a painfully slow, very difficult and generally discouraging experience. On my reporting for duty to Colonel Frank Moorman, who was Chief of the whole unit, I was asked whether I wished to be assigned to the cipher section or to the code section. Having had considerable experience with the solution of the former types of cryptosystems but none with the latter, and being desirous of gaining such experience, I asked to be assigned to the code-solving unit, in order to broaden by professional knowledge and practice in cryptology. Little did I realize what a painful and frustrating period of learning and training I had under-

taken, but my choice turned out to be a very wise and useful one. If any of you would like to ad about my experience in this area, let me refer you to my monograph, written in 1918–19, entitled *Field Codes Used by the German Army during the World War*, copies of which are on file in the Office of Training Services. I will quote the last two paragraphs from my "estimate of the three-letter code" (on p. 65 of that monograph) and will remind you that although they were written over 40 years ago they are still applicable:

> "In the light of this limited experience (of less than six months with the 3-letter code) it is impossible to say absolutely what the degree of security offered by such a highly developed system really is. There is no doubt but that it is very great. There is no doubt but that, with the proper precautions, careful supervision and control the employment of such a code by trained men offers the highest possible security for secret communication on the field of battle.
>
> But no code, no matter how carefully constructed, will be safe without trained, intelligent personnel. A poorly constructed code may be in reality more safe when used by an expert than a very well constructed one when used by a careless operator, or one ignorant of the dangers of improperly encoded messages. This point cannot be overemphasized. It is hardly necessary to point out, therefore, that the proper training of the personnel which is to be put in charge of the work of coding messages is an essential requisite to the maintenance of secrecy of operations, and thus of success on the field of battle."

So much for the German Army field codes, about which a great deal more could be said, but we must hurry on to the cryptosystems of some of the other armies in World War I.

What sorts of cryptosystems did the French Army use? First, as for ciphers, they put much trust in transposition methods, and here is an example of one type (Fig. 91). Perhaps you remember one of those special route ciphers I showed you in the preceding lecture, the one with the diagonal that produced complexities that made the use of that route too difficult for the cipher operators of the USMTC. This French transposition cipher was much more complicated by those diagonals, and I wonder how much use was made of it by the French.

As for codes, like the Germans, they used a small, front-line booklet called a "Carnet Réduit," or an "Abbreviated Codebook." Various sectors of the front had different editions, and I show you now a picture of one of them (Fig. 92). Then, in addition, there was a much more extensive code which was not only a two-part, randomized book of 10,000 four-digit code groups but a superencipherment was applied to the code messages when transmitted by radio or by "TPS," that is "telegraphie par sol," or earth telegraphy. Here is one of the tables used for enciphering (and deciphering) the code groups (Fig. 92), and here is the example of superencipherment given in the French code in my collection (Fig. 93).

You will notice that the enciphering process breaks up the 4-digit groups in a rather clever manner by enciphering the first digit of the first code group separately; the second and third digits of the first group are enciphered as a pair; then the last digit of the first group and the first digit of the second code group are enciphered as a pair, and so on. This procedure succeeds in breaking up the digital code groups in such a manner as to reduce very greatly the frequency of repetition of 4-digit groups representing words, numbers, phrases, etc., of very common occurrence in military messages. My appraisal of this French Army field cryptosystem is that, theoretically at least, it certainly was the most secure of all the field systems used by the belligerents.

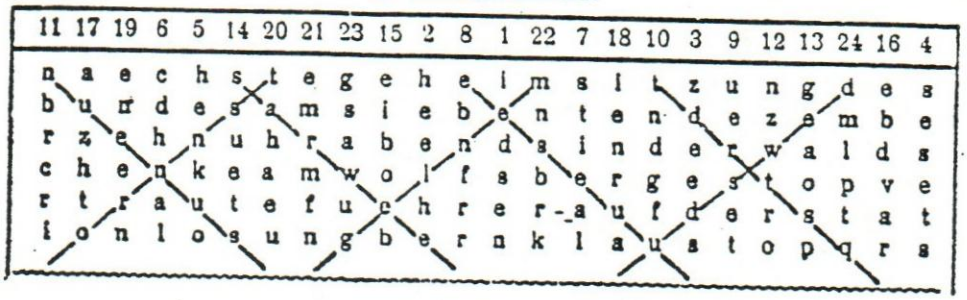
As for the Italians, the general level of cryptologic work in Italy during the period was quite low, a fact which is all the more remarkable when we consider that the birthplace of modern cryptology was in Italy several centuries before. There appears to have been in Italy a greater knowledge of cryptologic techniques in the 15th and 16th Centuries than in the 19th, paradoxical as this may seem to us today. Perhaps this can be considered as one of the consequences of the need for secrecy which requires filing away in dusty archives records of cryptanalytic successes; but it is to be considered also that this prevents those who might have a flair for cryptologic work from profiting from the progress of predecessors who have been successful

an—Artillerie

*an Stelle von	rzd	antreten	kwy
andauern	aic	Antwort	rtr
andere	rdn	anwesend	ugc
Änderung	sgr	Anzahl	snv
anfangen	awy	*Anzuge, im	ryd
anfordern	kaz	Apparat	uvd
Anforderung	rlf	Arbeit	kjy
Anfrage	ukt	arbeiten	apm
Angabe	sze	Armee	rdm
angeblich	aho	Armeeoberkommando (A.O.K.)	sgt
angegriffen	kuc	Artillerie	awv, kho
angreifen	uev	*eigene	rji, uln
Angriff	rtk	*feindliche	ste, agg
Angriffsstreifen	sqf	*Kommandeur d.	rvj
Angriffsvorbereitung	rzg	*leichte	rpq
anhalten	uyb	*schwere	sgx
anlegen	knz	Artillerie-Beobachter	kjn
*Anmarsch, im	ake	Artillerie-Feuer	rvi, ksi
Anmarschweg	kyy	*eigenes	uct, sjn
Annäherungsgraben	sdl	*feindliches	uyc, kke
Annäherungsweg	azs	Artillerie-Flieger	aot
anrufen	kdw	Artillerie-Meßtrupp	rei
Ansammlung	rgq	Artillerie-Stellung	kzu
anscheinend	uiy	Artillerie-Tätigkeit	scg
Anschluß	svl	Art.-Unterstützung	asr
ansetzen	afj	Artillerie-Verbindungsoffizier	kce, rhm
Blinde Signale			ugr, rif, seh, kqx, avd

Figure 90.

c. Einschreiben.



d. Sigelschrift.

eeseu utdrt sqnue nussa rweet snrom nlgde wsdid senhe ehzee ssese tshek ocdha lstia lbfrr ueetn dgfbr crinz rogao puete ibobe bdvar azhti enrae nenha euemm fnnbr kgsau mlpt

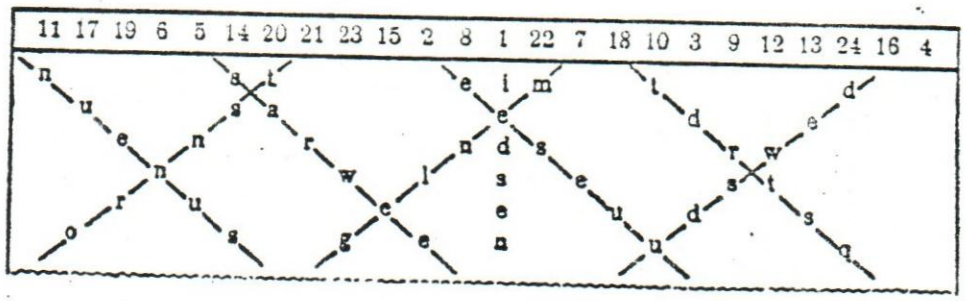
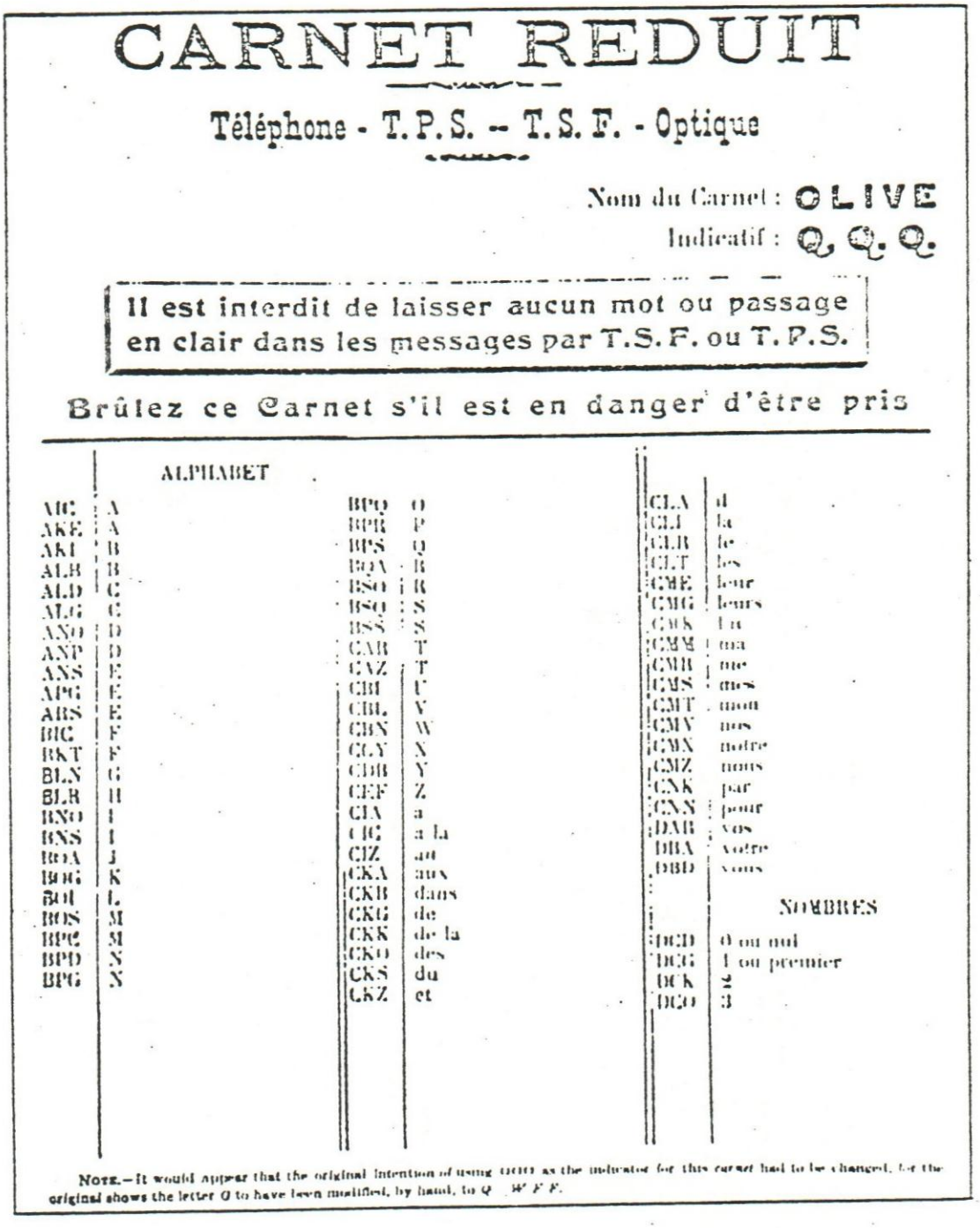


Figure 91.

in such work. We should not be too astonished to learn, therefore, that when Italy entered World War I the Italian Army put its trust in a very simple variation of the ancient Vigenère cipher, a system called the "cifrario militare tascabile" or the "pocket military cipher" (Fig. 96).

As regards Russian cryptographic work, it is known that there was, during the era of the last of the Czarist rulers, an apparently well organized and effective bureau for constructing and compiling diplomatic codes and ciphers, which had been organized by a Russian named Savinsky, formerly Russian Minister to Stockholm. He saw to it that all codes and cipher in use were improved; he introduced strict regulations for their use; and he kept close watch over the cryptographic service. He also was head of a cryptanalytic activity, and it is known that Turkish, British, Austrian and Swedish diplomatic messages were solved. After the Bolshevik revolution of 1916, some of the Russian cryptanalysts managed to escape from their homeland, and I had the pleasure of meeting and talking with one of the best of them during his service with one of our Allies in World War II. He is no longer alive, but I vividly recall that he wore with great pride on the index finger of his right hand a ring in which was mounted a large ruby. When I showed interest in this unusual gem, he told me the ring had been presented him as a sen of recognition and thanks for his cryptanalytic successes while in the service of Czar Nicholas, the last of the line.

But the story is altogether different as regards cryptology in the Russian Army. The Military Cryptographic Service was poorly organized and, besides, it had adopted a cryptographic system which proved to be too complicated for the poorly trained Russian cipher and radio operators to use when it was placed into effect toward the end of 1914. Here is a picture of that cipher (Fig. 97), which was composed of two tables, one arranged for convenience in enciphering and the other arranged for convenience in deciphering. In the enciphering table the



CARNET REDUIT

Téléphone - T.P.S. – T.S.F. - Optique

Nom du Carnet : OLIVE

Indicatif : Q, Q, Q.

Il est interdit de laisser aucun mot ou passage en clair dans les messages par T.S.F. ou T.P.S.

Brûlez ce Carnet s'il est en danger d'être pris

ALPHABET

AIC	A
AKE	A
AKI	B
ALB	B
ALD	C
ALG	C
ANO	D
ANP	D
ANS	E
APG	E
ARS	E
BIC	F
BKT	F
BLN	G
BLR	H
BNO	I
BNS	I
BOA	J
BOG	K
BOI	L
BOS	M
BPC	M
BPD	N
BPG	N

BPQ	O
BPR	P
BPS	Q
BQA	R
BSO	R
BSQ	S
BSS	S
CAB	T
CAZ	T
CBI	U
CBL	V
CBN	W
CLY	X
CDB	Y
CEF	Z
CIA	a
CIC	a la
CIZ	au
CKA	aux
CKB	dans
CKG	de
CKK	de la
CKO	des
CKS	du
CKZ	et

CLA	il
CLI	la
CLR	le
CLT	les
CME	leur
CMG	leurs
CMK	lui
CMM	ma
CMR	me
CMS	mes
CMT	moi
CMV	nos
CMX	notre
CMZ	nous
CNK	par
CNS	pour
DAR	vos
DBA	votre
DBD	vous

NOMBRES

DCD	0 ou nul
DCG	1 ou premier
DCK	2
DCO	3

NOTE.—It would appear that the original intention of using OCIO as the indicator for this carnet had to be changed, for the original shows the letter O to have been modified, by hand, to Q. W. F. F.

Figure 92.

CHIFFREMENT.		
0 – GS	30 – HR	70 – AN
1 – RH	31 – IA	71 – RB
2 – AM	32 – VS	72 – HN
3 – SI	33 – GU	73 – MH
4 – BH	34 – NH	74 – GD
5 – NS	35 – IS	75 – BU
6 – DA	36 – HD	76 – IE
7 – TD	37 – TA	77 – DM
8 – EA	38 – IB	78 – AI
9 – EB	39 – AE	79 – RN
00 – AT	40 – HT	80 – UH
01 – GA	41 – SD	81 – NR
02 – IM	42 – US	82 – AD
03 – DN	43 – DI	83 – DH
04 – GH	44 – EI	84 – GI
05 – MN	45 – BS	85 – ED
06 – HI	46 – GR	86 – HB
07 – VG	47 – MD	87 – NA
08 – UR	48 – IR	88 – ER
09 – AB	49 – EM	89 – EG
10 – BT	50 – AU	90 – SN
11 – BA	51 – SM	91 – AS
12 – RD	52 – DB	92 – MS
13 – ND	53 – HS	93 – BD
14 – AG	54 – GB	94 – IN
15 – TS	55 – UA	95 – DS
16 – EG	56 – DR	96 – HM
17 – AR	57 – BI	97 – EH
18 – SB	58 – TR	98 – GT
19 – BN	59 – EB	99 – GN
20 – ES	60 – AH	
21 – RT	61 – VN	
22 – HA	62 – TN	
23 – DG	63 – BG	
24 – SR	64 – MU	
25 – DE	65 – BR	
26 – DT	66 – NG	
27 – NU	67 – SH	
28 – GM	68 – UM	
29 – NB	69 – DH	

DECHIFFREMENT.		
AB – 09	EM – 49	ND – 13
AD – 82	ER – 88	NG – 66
AE – 39	ES – 20	NH – 34
AG – 14		NR – 81
AH – 60	GA – 01	NS – 5
AI – 78	GB – 54	NU – 27
AM – 2	GD – 74	
AN – 70	GH – 04	RB – 71
AR – 17	GI – 84	RD – 12
AS – 91	GM – 28	RH – 1
AT – 00	GN – 99	RN – 79
AU – 50	GR – 46	RT – 21
	GS – 0	
BA – 11	GT – 98	SB – 18
BD – 93	GU – 33	SD – 41
BE – 25		SH – 67
BG – 63	HA – 22	SI – 3
BH – 4	HB – 86	SM – 51
BI – 57	HD – 36	SN – 90
BM – 83	HG – 89	SR – 24
BN – 19	HI – 06	
BR – 65	HM – 96	TA – 37
BS – 45	HN – 72	TD – 7
BT – 10	HR – 30	TN – 62
BU – 75	HS – 53	TR – 58
	HT – 40	TS – 15
DA – 6		
DB – 52	IA – 31	UA – 55
DG – 23	IB – 38	UG – 9
DH – 69	IE – 76	UH – 80
DI – 43	IM – 02	UM – 68
DM – 77	IN – 94	UR – 08
DN – 03	IR – 48	US – 42
DR – 56	IS – 35	
DS – 95		VG – 07
DT – 26	MD – 47	VN – 61
	MH – 73	VS – 32
EA – 8	MN – 05	
EB – 59	MS – 92	
ED – 85	MU – 64	
EG – 16		
EH – 97	NA – 87	
EI – 44	NB – 29	

Figure 93.

1. Beispiel.

a. Cifrario tascabile.

•	a	b	c	d	e	f	g	h	i
a	10	11	12	13	14	15	16	17	18
b	11	12	13	14	15	16	17	18	19
c	12	13	14	15	16	17	18	19	20
d	13	14	15	16	17	18	19	20	21
e	14	15	16	17	18	19	20	21	22
f	15	16	17	18	19	20	21	22	23
g	16	17	18	19	20	21	22	23	24
h	17	18	19	20	21	22	23	24	25
i	18	19	20	21	22	23	24	25	26
j	19	20	21	22	23	24	25	26	27
k	20	21	22	23	24	25	26	27	28
l	21	22	23	24	25	26	27	28	29
m	22	23	24	25	26	27	28	29	30
n	23	24	25	26	27	28	29	30	31
o	24	25	26	27	28	29	30	31	32
p	25	26	27	28	29	30	31	32	33
q	26	27	28	29	30	31	32	33	34
r	27	28	29	30	31	32	33	34	35
s	28	29	30	31	32	33	34	35	36
t	29	30	31	32	33	34	35	36	37
u	30	31	32	33	34	35	36	37	38
v	31	32	33	34	35	36	37	38	39
w	32	33	34	35	36	37	38	39	40
x	33	34	35	36	37	38	39	40	41
y	34	35	36	37	38	39	40	41	42
z	35	36	37	38	39	40	41	42	43

•	j	k	l	m	n	o	p	q	r
a	19	20	21	22	23	24	25	26	27
b	20	21	22	23	24	25	26	27	28
c	21	22	23	24	25	26	27	28	29
d	22	23	24	25	26	27	28	29	30
e	23	24	25	26	27	28	29	30	31
f	24	25	26	27	28	29	30	31	32
g	25	26	27	28	29	30	31	32	33
h	26	27	28	29	30	31	32	33	34
i	27	28	29	30	31	32	33	34	35
j	28	29	30	31	32	33	34	35	36
k	29	30	31	32	33	34	35	36	37
l	30	31	32	33	34	35	36	37	38
m	31	32	33	34	35	36	37	38	39
n	32	33	34	35	36	37	38	39	40
o	33	34	35	36	37	38	39	40	41
p	34	35	36	37	38	39	40	41	42
q	35	36	37	38	39	40	41	42	43
r	36	37	38	39	40	41	42	43	44
s	37	38	39	40	41	42	43	44	45
t	38	39	40	41	42	43	44	45	10
u	39	40	41	42	43	44	45	10	11
v	40	41	42	43	44	45	10	11	12
w	41	42	43	44	45	10	11	12	13
x	42	43	44	45	10	11	12	13	14
y	43	44	45	10	11	12	13	14	15
z	44	45	10	11	12	13	14	15	16

•	s	t	u	v	w	x	y	z
a	28	29	30	31	32	33	34	35
b	29	30	31	32	33	34	35	36
c	30	31	32	33	34	35	36	37
d	31	32	33	34	35	36	37	38
e	32	33	34	35	36	37	38	39
f	33	34	35	36	37	38	39	40
g	34	35	36	37	38	39	40	41
h	35	36	37	38	39	40	41	42
i	36	37	38	39	40	41	42	43
j	37	38	39	40	41	42	43	44
k	38	39	40	41	42	43	44	45
l	39	40	41	42	43	44	45	10
m	40	41	42	43	41	15	10	11
n	41	42	43	44	45	10	11	12
o	42	43	44	45	10	11	12	13
p	43	44	45	10	11	12	13	14
q	44	45	10	11	12	13	14	15
r	45	10	11	12	13	14	15	16
s	10	11	12	13	14	15	16	17
t	11	12	13	14	15	16	17	18
u	12	13	14	15	16	17	18	19
v	13	14	15	16	17	18	19	20
w	14	15	16	17	18	19	20	21
x	15	16	17	18	19	20	21	22
y	16	17	18	19	20	21	22	23
z	17	18	19	20	21	22	23	24

•	0	1	2	3	4	5	6	7	8	9	•
a	36	37	38	39	10	41	42	43	44	45	a
b	37	38	39	40	41	42	43	44	45	10	b
c	38	39	40	41	42	43	44	45	10	11	c
d	39	10	41	42	43	44	45	10	11	12	d
e	40	41	42	43	44	45	10	11	12	13	e
f	41	42	43	44	45	10	11	12	13	14	f
g	42	43	44	45	10	11	12	13	14	15	g
h	43	44	45	10	11	12	13	14	15	16	h
i	44	45	10	11	12	13	14	15	16	17	i
j	45	10	11	12	13	14	15	16	17	18	j
k	10	11	12	13	14	15	16	17	18	19	k
l	11	12	13	14	15	16	17	18	19	20	l
m	12	13	14	15	16	17	18	19	20	21	m
n	13	14	15	16	17	18	19	20	21	22	n
o	14	15	16	17	18	19	20	21	22	23	o
p	15	16	17	18	19	20	21	22	23	24	p
q	16	17	18	19	20	21	22	23	24	25	q
r	17	18	19	20	21	22	23	24	25	26	r
s	18	19	20	21	22	23	24	25	26	27	s
t	19	20	21	22	23	24	25	26	27	28	t
u	20	21	22	23	24	25	26	27	28	29	u
v	21	22	23	24	25	26	27	28	29	30	v
w	22	23	24	25	26	27	28	29	30	31	w
x	23	24	25	26	27	28	29	30	31	32	x
y	24	25	26	27	28	29	30	31	32	33	y
z	25	26	27	28	29	30	31	32	33	34	z

•	a	b	c	d	e	f	g	h	i	•

•	j	k	l	m	n	o	p	q	r	•

b. Schlüsseln.

Klarschrift: D a s v i e r t e B a t a i l l o n h a l t v o n s e i n e r S t e l l u n g a m . . .
Schlüssel: i a m i t t e n m e i n e s l e b e n s w e g
Sigel: 39 31 26 35 12 33 15 23 41 14 26 34 25 42 34 32 30 18 34 39 16 27 22

c. Sigelschrift.

Der 3031 2635 1233 1523 4114 2534 2542 34 hat von seiner 3230 1834 3916 2722 am . . .

Figure 96.

ers of the Russian alphabet (33 in all) appear in the topmost row of characters, the 2-digit groups, in random order within each of the 8 rows below the top row, are their cipher equivalents. These rows therefore constitute a set of 8 cipher alphabets, these alphabets being preceded by key numbers from 1 to 8 in random order. Both the cipher equivalents and the indicators were subject to change. Indicators were used to tell how many letters were enciphered consecutively in each alphabet, the indicator consisting of one of the digits from 1 to 9 repeated five times. The alphabets were then used in key-number sequence, enciphering the first set of letters (5, 7, etc., according to the indicator) by alphabet 1, the next set by alphabet 2, and so on. After the 8th set of letters, which was enciphered by cipher alphabet 8, one returned to cipher alphabet 1, repeating the sequence in this manner until the entire message had been enciphered. In enciphering a long message the cipher operator could change the number of letters enciphered consecutively by inserting another indicator digit repeated five times and then continuing with the next alphabet in the sequence of alphabets. The cipher text was then sent in 5-digit groups. The use of the deciphering table hardly requires explanation but this question may be in order: Why the aversion to the use of zero and to the use of double digits such as 11, 22, 33, etc.? This probably was thought to be helpful to the telegraph operators as well as to the cipher clerks in straightening out errors in transmission and reception.

I have told you that this cipher system proved too difficult for the Russians to use, and I think you can see why. It was so difficult that messages had to be repeated over and over, with great loss of time. It is well known to all historians by this time that the Russians lost the Battle of Tannenberg in the autumn of 1914 largely because of faulty communications. Poor cryptography and failure to use even the most simple ciphers properly on the field of battle, and not brilliant strategy on the part of the enemy, was the cause of Russia's defeat in

Russischer Sprungchiffre.

a. Chiffrant.

•	а	б	в	г	д	е	ж	з	и	к	л	м	н	о	п	р	с	т	у	ф	х	ц	ч	ш	щ	ъ	ю	я	ь	ѣ	ы	і	й	•
3	31	61	81	79	57	35	12	56	46	74	37	41	89	43	45	47	97	65	32	59	24	39	38	86	13	84	23	85	62	17	54	58	14	3
1	31	21	81	79	42	56	72	26	83	27	37	61	89	43	28	23	97	13	29	59	36	32	38	73	63	24	64	85	41	17	25	51	46	1
4	15	37	21	64	31	17	67	25	49	69	18	23	35	93	59	86	52	13	46	89	74	98	28	47	72	42	45	24	48	87	34	65	39	4
5	86	92	52	23	18	97	36	13	46	67	54	71	19	14	65	27	93	85	16	79	12	58	76	48	83	34	26	74	62	38	37	29	81	5
6	25	31	17	42	38	13	41	61	23	45	89	15	84	75	48	54	34	73	14	53	37	24	64	18	28	12	95	57	93	78	82	76	27	6
7	41	64	84	43	92	53	85	34	67	71	27	26	46	49	24	58	31	75	18	23	98	29	62	39	42	51	95	65	17	96	13	91	94	7
8	12	56	82	74	13	38	96	54	61	37	83	26	49	68	39	65	57	16	23	95	48	31	78	17	59	73	14	72	98	52	41	53	69	8
2	73	86	31	93	42	56	21	62	19	47	75	61	32	59	28	84	14	71	35	91	87	69	16	13	25	76	89	38	64	94	95	83	29	2
•	a	b	w	g	d	e	že	ze	i	k	l	m	n	o	p	r	s	t	u	f	h	c	č	š	šč	jer	ju	ja	jerj	jerr	jerrü	i	y	•

b. Dechiffrant.

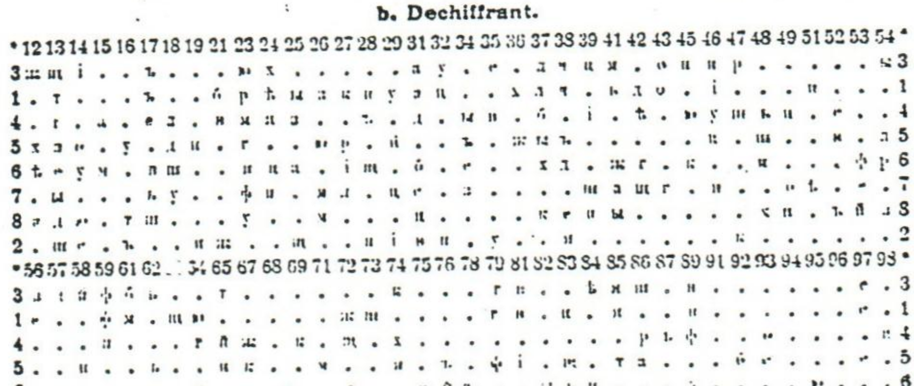


Figure 97.

that and in subsequent battles. The contents of Russian communications became known to the German and Austrian High Commands within a few hours after transmission by radio. The disposition and movements of Russian troops and Russian strategic plans were no secrets to the enemy. The detailed and absolutely reliable information obtained by intercepting and reading the Russian communications made it very easy for the German and Austrian commanders not only to take proper counter measures to prevent the execution of Russian plans but also to launch attacks on the weakest parts of the Russian front. Although the Russian ciphers were really not complicated, their cipher clerks and radio operators found themselves unable to exchange messages with accuracy and speed. As a matter of fact, they were so inept that not only were their cipher messages easily solved but also they made so many errors that the intended recipients themselves had considerable difficulty in deciphering the messages, even with the correct keys. In some cases this led to the use of plain language, so that the German and Austrian forces did not even have to do anything but intercept the messages and translate the Russian. To send out dispositions, impending movements, immediate and long-range plans in plain language was, of course, one cardinal error. Another was to encipher only words and phrases deemed the important ones, leaving the rest in clear. Another cardinal error, made when a cipher was superseded, was to send a message to a unit that had not yet received the new key and, on learning this, to repeat the identical message in the old key. I suppose the Russians in World War I committed every major error in the catalog of crypto-criminology. No wonder they lost the Battle of Tannenberg, which one military critic said was not a battle but a massacre, because the Russians lost 100,000 men in the 3-day engagement, on the last day of which the Russian commander-in-chief committed suicide. Three weeks later another high Russian commander followed suit, and the Russian Army began to fall apart, completely disorganized, without leadership or plans. Russia itself began to go down in ruins when its Army, Navy and Government failed so completely, and this made way for the October revolution, ushering in a regime that was too weak to put things together again. The remnants were picked up by a small band of fanatics with military and administrative ability. By treachery, violence and cunning, they welded together what has now become a mighty adversary of the Western World, the USSR.

I have left to be treated last in this lecture the cryptosystems used by the American Expeditionary Forces in Europe during our participation in World War I.

When the first contingents of the AEF arrived in France in the summer of 1917, there were available for secret communications within the AEF but three authorized means. The first was the extensive code for administrative telegraphic correspondence, the 1915 edition of the *War Department Telegraph Code* about which I've already told you something. Although it was fairly well adapted for that type of communication, it was not at all suitable for rapid and efficient strategic or tactical communications in the field, nor was it safe to use without a clumsy superencipherment. The second cryptosystem available was that known as the repeating-key cipher, which used the Signal Corps Cipher Disk, the basic principles of which were described as far back as about the year 1500. The third system available was the Playfair Cipher, which had been frankly copied from the British, who had used it as a field cipher for many years before World War I and continued to use it. In addition to these authorized means there were from time to time current in the AEF apparently several—how many, no one knows—unauthorized, locally improvised "codes" of varying degrees of security, mostly nil. I show one of these in this slide (Fig. 98) and will let you assess its security yourself.

Seen in retrospect, when the AEF was first organized it was certainly unprepared for handling secret communications in the field; but it is certain that it was no more unprepared in this respect than was any of the other belligerents upon their respective entries into World War I, as I've indicated previously in this lecture. This is rather strange because never before in the history of warfare had cryptology played so important a role as a consequence of advances in electrical communications technology. When measured by today's standards it must be said that not only was the AEF on its arrival in Europe wholly unprepared as to secret

Headquarters
52nd Infantry Brigade
26th Division
A.E.F.

France, 17 April 1918.

BULLETIN
No. 1

The following code for communications between Companies, Battalions, Regiments and Headquarters 52nd Infantry Brigade will be effective 18 April 1918, 12 o'clock.

CASUALTIES

KILLED.....Strike out
SERIOUSLY WOUNDED.....Base on balls
SLIGHTLY WOUNDED.....Hit by pitched ball
ACCIDENTALLY WOUNDED.....Balk
MISSING.....Put outs
COMMISSIONED OFFICER.....Major
ENLISTED MEN.....Minors

CAPTURES

HAVE TAKEN (No)_____PRISONERS.....Stolen Bases_____(NO)
Have Lost (NO)_____PRISONERS.....Left on Bases_____(NO)
HAVE LOST MACHINE GUNS.....Errors
HAVE TAKEN MACHINE GUNS.....Assists

ARTILLERY, TRENCH WEAPONS

WE WERE BOMBARDED BY MINENWERFERS.....Johnson using spit ball
WE BOMBARDED WITH TRENCH MORTARS.....Leonard using slow ball
WE BOMBARDED WITH STOKES MORTARS.....Leonard using spit ball
WE BOMBARDED WITH 37 M.M. CANON.....Leonard using a curve
FIRED ON BY MACHINE GUNS.....Johnson using fast ball
FIRED WITH MACHINE GUNS.....Leonard using fast ball
WE WERE UNDER BOMBARDMENT.....Wagner at bat
WE WERE UNDER HEAVY BOMBARDMENT.....Wagner knocked a home run
WE WERE UNDER MODERATE BOMBARDMENT.....Wagner tripled
WE WERE UNDER LIGHT BOMBARDMENT.....Wagner doubled
WE WERE BOMBARDED WITH GAS.....Wagner singled
ENEMY REGISTRATION FIRE.....Wagner walked
WE BOMBARDED.....Cobb at bat
WE BOMBARDED HEAVILY.....Cobb knocked a home run
WE BOMBARDED MODERATELY.....Cobb tripled
WE BOMBARDED LIGHTLY.....Cobb doubled
WE BOMBARDED WITH GAS.....Cobb singled
REGISTRATION FIRE (OURS).....Cobb walked
BARRAGE REQUESTED FROM_____.....to_____fanned
OUR ARTILLERY LAID DOWN A BARRAGE.....Sent in a pinch hitter

MISCELLANEOUS

NO UNUSUAL TRENCH EVENTS.....Game called, rain
QUIET DAY.....Game called darkness
ACTIVE DAY.....Extra inning game
THE ENEMY IS DOING TRENCH WORK at_____.....He is warming up
WE ARE DOING TRENCH WORK at_____.....We are warming up

Figure 98.

communication means and methods and as to cryptanalysis, but for a limited time it seemed almost hopeless that the AEF could catch up with the technical advances both sides had made, because their British and French allies were at first most reluctant to disclose any of their hard-earned information about these vital matters.

Nevertheless, and despite so inauspicious a commencement, by the time of the Armistice in November 1918, not only had the AEF caught up with their allies but they had surpassed them in the preparation of secret codes, as may be gathered from the fact that their allies had by then decided to adopt the AEF system of field codes and methods for their preparation, printing, distribution, and usage.

Just as the invention of Morse wire telegraphy had a remarkable effect upon military communications during the American Civil War, as related in the preceding lecture, so the invention of radio also played a very important role in field communications during World War I. Now, although it can hardly be said that all commanders from the very earliest days of the use of radio in military communications acutely recognized one of the most important disadvantages of radio—namely, the fact that radio signals may be more-or-less easily intercepted by the enemy—it was not long before the consequences of a complete disregard of this obvious fact impressed themselves upon most commanders, with the result that the transmission of plain language became the exception rather than the rule. This gave the most momentous stimulus to the development and increased use of cryptology that this service had ever experienced.

Let us review some of the accomplishments of the Code Compilation Service under the Signal Corps, AEF. It was organized in January 1918, and consisted of one captain, three lieutenants and one enlisted man. Until this service was organized, that is, from the summer of 1917 until the end of that year, the AEF had nothing for cryptocommunications except those three inadequate means which I've mentioned. When it had been determined that field codes were needed, little time was lost in getting on with the job that had to be done. Since I had no part in this effort, I can say, without danger of being charged with impropriety, that the Code Compilation Service executed the most remarkable job in the history of military cryptography up to the time of World War II.

The first work entrusted to it was the compilation of a so-called "Trench Code," of which 1000 copies were printed, together with what were then called "distortion tables." These were simple monoalphabets for enciphering the 2-letter groups of the code. I will show you a picture of a page of this code (Fig. 99) and of one of the "distortion tables" (Fig. 100). The danger of capture of these codes was recognized as being such that the books were not issued below battalions. Hence, to meet the needs of the front line, a much smaller book was prepared and printed, called the "Front Line Code." Distortion tables, 30 of them in all, were issued to accompany this code, of which an edition of 3,000 copies was printed. But the code was not distributed, because a study of its security showed defects. The truth is that AEF cryptographers with personnelin experienced in cryptanalysis were groping in the dark, with little or no help from allies. Finally, the light broke through: the Code Compilation Service began to see the advantages of that German 3-letter randomized 2-part code I've told you about, the one called the *Satzbuch*. Here, then, was the origin of the Trench Codes which were finally adopted and used by the AEF, when it was decided that copying and benefitting from the experience of German code compilers was no dishonor. But the AEF then went them one better, as you shall now learn. The first code of the new series of the AEF field codes was known as the "Potomac Code"; it was the first of the so-called "American River Series," and it appeared on 24 June 1918, in an edition of 2,000 copies (Fig. 101). It contained approximately 1,700 words and phrases and, as the official report so succinctly states, "was made up with a coding and decoding section in order to reduce the work of the operators at the front." The designation "two-part," "randomized," or, least of all, the British nomenclature, a "hatted" code, was still unknown—but the principle was there nonetheless. Let us see what the official report goes on to say on this point; let us listen to some sound common sense:

51 OB.....Advance
52 OC.....Advance guard
53 OD.....Advancing
54 OF.....Advantage
55 OG.....Aeroplane (s)
56 OK.....Aeroplane observation
57 OL.....Aeroplane wireless
58 OM.....After
59 ON.....Afternoon
60 OP.....Again
61 OR.....Against
62 OS.....Age
63 OT.....Aim
64 OV.....Air
65 OW.....-Al
66 OZ.....Alert
67 UB.....All
68 UC.....All clear
69 UD.....All communication has been cut (with)
70 UF.....All is well
71 UG.....All of your messages have been received
72 UH.....All ready
73 UK.....All returned
74 UL.....All right
75 UM.....Alone
76 UN.....Along
77 UP.....Already
78 UR.....Also
79 US.....Alter
80 UT.....Altogether
81 UV.....Always
82 UW.....Am
83 UZ.....Am having
84 YB.....Am I
85 YC.....Am not
86 YD.....Ambulance (s)
87 YF.....Ambush
88 YG.....Ammunition
89 YH.....Ammunition depot (s)
90 YK.....Ammunition exhausted
91 YL.....Ammunition for 75 m.m. Field Gun, reduced charge, explosive projectile
92 YM.....Among
93 YN.....Amplifier
94 YP.....An
95 YR.....-Ance
96 YS.....And
97 YT.....Angle
98 YV.....Annihilate
99 YW.....Announce
00 YZ.....Annoy

—ed—1721—HEG
—ing—1999—LYW
—ly—2083—MUZ
—ment—2121—NEG

Figure 99.

2-a

THIS TABLE MUST NOT FALL INTO THE HANDS OF THE ENEMY.

1. If destroyed to prevent capture, report will be made to the office to which its return is ordered.

2. This table will be used from 3 a.m.....

to 3 a. m....., after which it will be returned in sealed envelope to .....

ENCIPHER

A	B	C	D	E	F	G	H	I	K	L	M	N	O	P	R	S	T	U	V	W	Y	Z
h	o	m	s	v	a	r	e	c	z	k	n	f	l	u	w	y	i	t	b	d	p	g

DECIPHER

a	b	c	d	e	f	g	h	i	k	l	m	n	o	p	r	s	t	u	v	w	y	z
F	V	I	W	H	N	Z	A	T	L	O	C	M	B	Y	G	D	U	P	E	R	S	K

Key word .....

Service message .....

Private message .....

Figure 100.

DECODING

ABE...Falling back
ABF...Heavy
ABG...Message received
ABK...Supply
ABM...Have you received
ABO...Bombardment
ABP...Barrage
ABS...Battalion
ABV...Automatic
ABW...Must be
ABX...Truck
ABY...Received
AFC...Cannot
AFD...One
AFJ...Turn
AFM...Machine gun emplacement
AFO...Enemy
AFR...7
AFV...18
AFX...Smoke
AFY...Stop
AGE...Diminish
AGF...-en
AGH...Picket
AGK...Stay
AGL...Field buzzer
AGN...In communication with
AGO...Question
AGU...Lieutenant
AGY...Emplacement
AMC...Further
AMG...Wounded
AMK...We are losing heavily
AMO...At close quarters
AMP...Confirm
AMS...Our first line
AMV...-ate
AMX...Might
AMY...Evident
AND...Battalion
ANF...During the night
ANG...Fifth
ANK...All stations
ANP...Observer
ANO...31
ANS...Consider
ANW...36
ANX...Your
ANY...Within
APB...Bombproof
APE...Relief completed
APF...Retire
APJ...Premature
APN...Impossible
APO...Withdraw
APU...Machine gun ammunition
APW...E
APX...Remove
APY...Moving
ASB...92
ASF...Shell
ASG...T
ASK...Has not been
ASM...Gas is being blown back
ASO...Control
ASP...Removed
ASV...Keep
ASX...Surprise
ASY...(Null)
AUB...Runner
AUF...Must have
AUG...Condition
AUK...Safety
AUM...Minute
AUP...Rescue
AUS...Point
AUW...V. B. rocket
AUX...On the right
AWB...Sometime
AWC...Require
AWE...Barricade
AWG...O'clock
AWK...Light signal
AWO...Double
AWP...Still
AWS...Lengthen
AWX...Will signal by
AWY...Will not
AXB...Forcing
AXF...Magazine
AXG...Trenches
AXM...45
AXP...Send
AXS...Moment
AXV...Your
AXW...Last night
AXY...Going
BAD...Advance
BAF...Afternoon
BAG...Division headquarters

Figure 101.

"The main point of difference from other Army codes lay in the principle of reprinting these books at frequent intervals and depending largely upon the rapidity of the reissuance for the secrecy of the codes. This method did away with the double work at the front of ciphering and deciphering, and put the burden of work upon general headquarters, where it properly belonged. Under this system one issue of codes could be distributed down to regiments; another issue held at Army Headquarters; and a third issue held at General Headquarters. As a matter of record this first book, the Potomac, was captured by the enemy on July 20, just one month after issuance, but within two days, it had been replaced throughout the entire Army in the field."

The replacement code was the Suwanee, the next in the River Series, followed by the Wabash, the Allegheny and the Hudson, all for the American First Army. In October 1918 a departure in plan was made, and different codes were issued simultaneously to the First and Second Armies. This was done in order not to jeopardize unnecessarily the life of the codes by putting in the field at one time 5,000 or 6,000 copies of any one issue. Thus the Champlain, the first of what came to be called the "Lake Series," for the Second Army, was issued with the Colorado of the "River Series" for the First Army; these were followed by the Huron and the Osage, the Seneca and the Niagara, in editions of 2,500 each.

In addition to the foregoing series of codes were certain others that should be mentioned, as for example, a short code of 2-letter code groups to be used by front line troops as an emergency code; a short code list for reporting casualties; a telephone code for disguising the names of commanding officers and their units, and so on. But there was in addition to all the foregoing, one large code that must be mentioned, a code to meet the requirements for secure transmission of messages among the higher commands in the field and between these and GHQ. This was a task of considerable magnitude and required several months' study of messages, confidential papers concerning organizations, replacements, operations, and of military documents of all sorts. The code was to be known as the AEF Staff Code. In May 1918, the manuscript of this code was sent to press, and the printing job was done in one month by the printing facilities of the AEF Adjutant General. Considering that the code contained approximately 30,000 words and phrases, accompanied by code groups consisting of 5-figure groups and 4-letter groups, the task completed represents a remarkable achievement by a field printing organization, and I believe that this was the largest and most comprehensive codebook ever compiled and printed by an army in the field. More than 50,000 telegraphic combinations were sent in tests in order to cast out combinations liable to error in transmission. One thousand copies of this code were printed and bound. With this code, as a superencipherment system, there were issued from time to time "distortion tables." There remains only to be said that the war was over before this code could be given a good work out, but I have no doubt that during the few months it was in effect it served a very useful purpose. Moreover, the excellent vocabulary was later used as a skeleton for a new War Department Telegraph Code to replace the edition of 1915.

One more code remains to be mentioned: a "Radio Service Code," the first of its kind in the American Army. This was prepared in October, to be used instead of a French code of similar nature. Finally, anticipating the possible requirement for codes for use by the Army of Occupation, a series of three small codes, identical in format with the war time trench codes of the River and Lake series, was prepared, and printed. They were named simply Field Codes No. 1, 2 and 3 but were never issued because there turned out to be no need for them in the quietude in Germany after the Army of Occupation marched into former enemy, but now very friendly, territory.

I will bring this lecture to a close now by referring those of you, who might wish to learn more about the successes and exploits of the cryptographic organization of the AEF in World War I, to my monograph entitled *American Army Field Codes in the American Expeditionary Forces during the First World War*, Government Printing Office, 1942. Copies are on file in the Office of Training Services. In that monograph you will find many details of interest

which I have had to omit in this talk, together with many photographs of the codes and ciphers produced and used not only by the AEF but also by our allies and enemies during that conflict.

* * * *

In Lecture IV two USMTC cipher messages were given and I said that their solutions would be presented at the conclusion of the next lecture. Here they are, both being from Major General Buell to General-in-Chief Halleck, relating to the relief and reinstatement of Buell.

Louisville, Ky., September 29, 1862

Maj. Gen. Halleck, General-in-Chief:

I have received your orders of the 24th inst., requiring me to turn over my command to Maj. Gen. G. H. Thomas. I have accordingly turned over the command to him, and in further obedience to your instructions, I shall repair to Indianapolis and await further orders.

D. C. Buell,
Major-General

Louisville, Ky., September 30, 1862

General Halleck:

I received last evening your dispatch suspending my removal from command. Out of a sense of public duty, I shall continue to discharge the duties of my command to the best of my ability until otherwise ordered.

D. C. Buell,
Major-General

Lecture VI

This, the sixth and final lecture in this series on the history of cryptology, will be devoted to a presentation of the events of importance in that history from the end of World War I to the end of World War II. It would be entirely too ambitious a project even to attempt to compress within a lecture of only fifty minutes all that should or could be told in that segment of our history. Briefly, however, it can be said that the most significant events during that quarter of a century were directly concerned firstly, with the advances made in the production of more complex mechanical, electrical, and electronic cryptographic apparatus and, secondly, with the concomitant advances in the production of more sophisticated cryptanalytic apparatus in order to speed up or to make possible the solution of enemy communications produced by these increasingly complex cryptographic machines. These two phases are interrelated because, to use a simple analogy, cryptography and cryptanalysis represent the obverse and reverse faces of a single coin.

As to advances in the development and use of more effective cryptographic apparatus I will only note at this point a comment which General Omar Bradley of World War II fame makes in his very interesting book, *A Soldier's Story*:[1]

> Signal Corps officers like to remind us that "although Congress can make a general, it takes communications to make him a commander."

It is presumptuous to amend General Bradley's remark but this is how I wish he had worded it:

> Signal Corps officers like to remind us that "although Congress can make a general, it takes *rapid and secure* communications to make him a good commander."

This will in fact be the keynote of this lecture. In other words, *communication security*, or COMSEC, will be its main theme and the one I wish to emphasize.

But before we take up the cryptographic history of the years between 1918 and 1946, perhaps a bit more attention must be devoted to events and developments of cryptanalytic significance or importance during this period. By far the most spectacular and interesting of these are the ones which were so fully and disastrously disclosed by the various investigations conducted by the Army and Navy very secretly while World War II was still in progress, and both secretly and openly after the close of hostilities. The investigations were intended to ascertain why our Army and Navy forces in Hawaii were caught by surprise by the sneak attack on Pearl Harbor by the Japanese on the morning of 7 December 1941. They were also intended to ascertain and pin the blame on whoever was responsible. I don't think I should even attempt to give you my personal opinion on these complex questions, which were studied by seven different boards within the Services and finally by the *Joint Congressional Committee on the Investigation of the Pearl Harbor Attack*. I mentioned the latter investigation in my first lecture and now will add to what I said then. The committee began its work early in September 1945 with secret hearings, but on 70 days between 15 November 1945 and 31 May 1946, open hearings were conducted, in the course of which some 15,000 pages of testimony were taken and a total of 183 exhibits received, incident to an examination of 43 witnesses. In July 1946 the committee put out a final report of 580 pages containing its findings, conclusions and recommendations. The report was accompanied by a set of 39 volumes of testimony and exhibits. The report was really not a single report: there was one by the Majority (signed by six Dem-

[1] New York: Henry Holt and Co., 1951, p 474.

cratic and two Republican members), and one by the Minority (signed by two Republican members). The Minority Report was not nearly as long as that of the Majority, but it brought into focus certain troublesome points which still form the subject of acrimonious discussions and writings by those who believe the attack was "engineered" by President Roosevelt and that certain authorities in Washington were as culpable as were the principal commanders in the Army and in the Navy in Hawaii.

For this lecture, however, it is an interesting fact that both the Majority and Minority Reports contain glowing tributes to the role played by COMINT before and during our participation in World War II. In my first lecture, I presented a brief extract in this regard, taken from the Majority Report;[2] but here is what the Minority Report says on the subject:[3]

> "Through the Army and Navy intelligence services extensive information was secured respecting Japanese war plans and designs, by intercepted and decoded Japanese secret messages, which indicated the growing danger of war and increasingly after November 26 the imminence of a Japanese attack.
>
> With extraordinary skill, zeal, and watchfulness the intelligence services of the Army Signal Corps and Navy Office of Naval Communications broke Japanese codes and intercepted messages between the Japanese Government and its spies and agents and ambassadors in all parts of the world and supplied the high authorities in Washington reliable secret information respecting Japanese designs, decisions, and operations at home, in the United States, and in other countries. Although there were delays in the translations of many intercepts, the intelligence services had furnished to those high authorities a large number of Japanese messages which clearly indicated the growing resolve of the Japanese Government on war before December 7, 1941."

Although references to COMINT abound in the Report of the Majority as well as in the Report of the Minority, there are also many references having to do with COMSEC in both Reports, as well as in the 39 accompanying volumes of testimony and exhibits. Some technical misconceptions with regard to those subjects are there, too, and it is quite comprehensible that there should be some on the part of laymen, but to encounter a serious one in a book by an experienced high-level commander in World War II is a bit disconcerting. Listen to this paragraph from a recent book by General Wedemeyer, who was one such commander:[4]

> "The argument has been made that we could not afford to let the Japanese know we had broken their code. But this argument against a Presidential warning does not hold water. It was not a mere matter of having broken a specific code; what we had done was to devise a machine which could break *any* [author's emphasis] code provided it was fed the right combinations by our extremely able and gifted cryptographers. The Japanese kept changing their codes throughout the war anyway. And we kept breaking them almost as a matter of routine."

I don't know where General Wedemeyer obtained his information about that wonderful machine he mentions. I imagine that there are many other persons who think there is such a machine because of all they hear and see about those marvelous "electronic brains" which are capable of performing such amazing feats in solving all kinds of problems. I daresay I won't be wrong in assuming that many of you do indeed wish there were such a machine as that mentioned by General Wedemeyer. Nobody doubts that electronic digital computers can do lots of things in cryptologic research, and many persons speculate on the role they may play in their possible applications in connection with such research in future wars.

But let's leave such speculations, interesting as they may be, and continue with our history of past applications. Let's first dispose of some comments in the COMINT area of that history, not only on the events preceding the Pearl Harbor attack, but also on the military, naval and air operations which ensued in the Pacific as well as in the European Theatre.

You will recall that in my first lecture I called to your attention an article which appeared in the 17 December 1945 issue of *Time* magazine and which was based upon a letter that the

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[2] The 79th Congress, 2nd Session, Senate Document No. 244, Washington: The Government Printing Office, 1946, p. 232.

[3] *Ibid*, page 514.

[4] Wedemeyer, General Albert C.; *Wedemeyer Reports*, Henry Holt and Company, New York: 1958, p. 430.

late General Marshall wrote to Governor Dewey, Republican candidate for President in the 1944 campaign. Here's how the two principals looked at that time (Fig. 102). In the letter, which was written on 27 September 1944 and hand-carried by Colonel Carter W. Clarke, a high-level officer in Army G-2, to Governor Dewey, General Marshall begged the Governor to say nothing during the campaign about a certain piece of very vital information which had become known to the Governor, it having been "leaked" to him by persons unknown and unauthorized to disclose it. The information dealt with the fact that U.S. Government authorities had been reading Japanese codes and ciphers *before* the attack on Pearl Harbor. The points which General Marshall wanted to convey were that not only was the "leaked" information true, but much more important were the facts that (1) the war was still in progress; (2) the Japanese were still using certain of the pre-Pearl Harbor cryptosystems; and (3) the U.S. Government was still reading highly secret Japanese messages in those systems, as well as highly secret messages of other enemy governments. Therefore, it was absolutely vital that Governor Dewey not use the top secret information as political ammunition in his campaign.

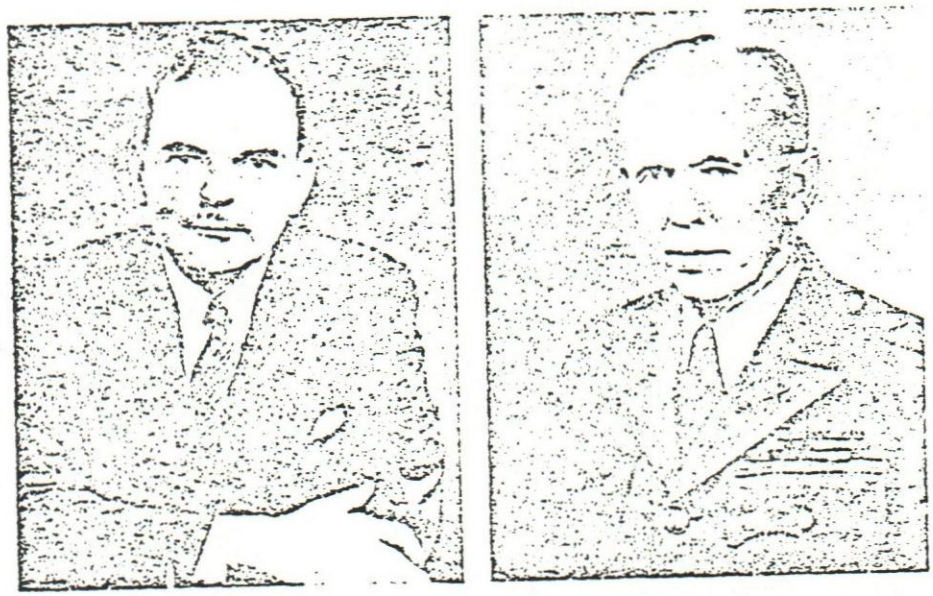

Figure 102.

After merely glancing over the first two paragraphs of the letter, Governor Dewey handed it back to Colonel Clarke with the comment that he did not wish to read any further, whereupon there was nothing for Colonel Clarke to do but return immediately to Washington. General Marshall then made certain changes in the opening paragraphs of the letter and again Colonel Clarke hand-carried it to the Governor, who then read the whole of it. In my first lecture I said that I might later give further extracts from *Time's* account of this episode, but there isn't time. Instead, however, I've put the whole account in Appendix I to the present lecture. The Marshall-Dewey correspondence is so important in cryptologic history that I have deemed it useful to put the whole of it in Appendix II.[5]

The information disclosed during the various official investigations of the attack on Pearl Harbor, so far as concerns the important COMINT achievements of the Army and the Navy before and after that attack, was classified information of the very highest security level, and the disclosures were therefore highly detrimental to our national security. Much has been written about them since the end of hostilities and although all of that formerly top secret

[5] See p. 118.

formation is now in the public domain, fortunately very few details of technical significance : value can be found therein. Hints and even blunt statements about the great role played by COMINT in U.S. military, naval and air operations are found in books and articles published by U.S. Government officials and American officers, as well as by officers of the beaten Japanese, German, and Italian armed forces. In the interests of brevity, I will cite only a few examples.[6]

As regards disclosures by U.S. Government officials and officers, I can begin with those of the late Mr. Cordell Hull, who was Secretary of State at the time of the Pearl Harbor attack. In his memoirs are many references (over a dozen) to the contents of intercepted and solved Japanese Foreign Office messages.[7] The late Mr. Henry L. Stimson, Secretary of War at that time, makes clear references in his autobiography to COMINT successes and our failure to use them prior to the attack.[8] Dr. Herbert Feis, who was Mr. Hull's adviser on international economic affairs from 1937 to 1943, and from 1944 to 1946 was Mr. Stimson's Special Consultant, has a good deal to say about the role played by "Magic" in a book written as a member of the Institute for Advanced Study, at Princeton.[9] Admiral Kimmel, one of the two commanders in Hawaii at the time of the attack, in defending himself in his book, cites many "Magic" messages.[10] And Major General Sherman Miles, head of G-2 at the time of the attack, has much to say about "Magic" in an article published in 1948.[11] As regards disclosures by former enemy officers, the following are of particular interest because they concern the Battle of Midway, which is considered the one that turned the tide of war in the Pacific from a possible Japanese victory to one of ignominious defeat:

> "If Admiral Yamamoto and his staff were vaguely disturbed by the persistent bad weather and by lack of information concerning the doings of the enemy, they would have been truly dismayed had they known the actual enemy situation. Post-war American accounts make it clear that the United States Pacific Fleet knew of the Japanese plan to invade Midway even before our forces had sortied from home waters. As a result of some amazing achievements by American intelligence, the enemy had succeeded in breaking the principal code then in use by the Japanese Navy. In this way the enemy was able to learn of our intentions almost as quickly as we had determined them ourselves."
>
> . . . . . .
>
> "The distinguished American Naval historian, Professor Samuel E. Morison, characterized the victory of United States forces at Midway as "a victory of intelligence." In this judgment the author fully concurs, for it is beyond the slightest possibility of doubt that the advance discovery of the Japanese plan to attack was the foremost single and immediate cause of Japan's defeat. Viewed from the Japanese side, this success of the enemy's intelligence translates itself into a failure on our part—a failure to take adequate precautions for guarding the secrecy of our plans. Had the secret of our intent to invade Midway been concealed with the same thoroughness as the plan to attack Pearl Harbor, the outcome of this battle might well have been different. But it was a victory of American intelligence in a much broader sense than just this. Equally as important as the positive achievements of the enemy's intelligence on this occasion was the negatively bad and ineffective functioning of Japanese intelligence."[12]

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[6] A good bibliographical survey of items concerning the attack up to the year 1955 will be found in the following: Morton, Louis. "Pearl Harbor in Perspective," *U.S. Naval Institute Proceedings*, Vol. 81, No. 4, Whole No. 626, April 1955, pp. 461-8.

[7] *The Memoirs of Cordell Hull*, New York: The MacMillan Co., 1948, Vol. II, pp. 998, 1013, 1035, 1055, 1056-7, 1060, 1063, 1068, 1074, 1077, 1087, 1092, 1095, 1096, 1099-1100.

[8] Stimson, Henry L., and McGeorge Bundy, *On Active Service in Peace and War*, Harper & Brothers, New York 1947, pp. 391-4, 454-5.

[9] Feis, Herbert, *The Road to Pearl Harbor*, Princeton: The Princeton University Press, 1950, p. vii, and pp. 219-340, *Passim*. (See index under "Magic" on p. 350).

[10] Kimmel, Husband E., *Admiral Kimmel's Story*, Henry Regnery Co., Chicago: 1954.

[11] Miles, Sherman, "Pearl Harbor in Retrospect," *The Atlantic Monthly*, Vol. 182, No. 1, July 1948, pp. 65-

[12] *Midway, The Battle that Doomed Japan: The Japanese Navy's Story*, by Matsuo Fuchida and Matasake Okumiya, U.S. Naval Institute Publication, Annapolis, 1955, pp. 131, and 232. Admiral Morison actually wrote: "Midway was a victory of intelligence bravely and wisely applied." See Vol. IV of his *History of*

It is the second extract above which is of special interest to us at the moment, and, in particular, the portion which refers to "the negatively bad and ineffective functioning of Japanese intelligence." The author is, I think, a bit too severe on the Japanese intelligence organization. I say this because their cryptanalysts were up against much more sophisticated cryptosystems than they dreamt of, or were qualified to solve. In fact, even if they had been extremely adept in cryptanalysis it would have been of no avail—U.S. high-level communications were protected by cryptosystems of very great security.

This brings us to a phase of cryptology which is of highest importance—the phase which deals with communications security, or COMSEC, and I shall confine myself largely to its development and historical background in our Armed Forces. The background is a very broad one because it should include the background of the developments of each of the three components of COMSEC, *viz*, (1) cryptosecurity, (2) transmission security, and (3) physical security of cryptomaterials. But since time is limited and because I think you would be more interested in the phases pertaining to cryptosecurity, I will omit further references to the other two components or to the history of their development. And even in limiting the data to cryptosecurity, I will have opportunity only to give some of the highlights of the development of the items that comprise our present cryptomaterials, omitting comments on the history of the development and improvement of our techniques, procedures and practices, all of which are extremely important.

I shall begin the story with a definition which you will find in any good English dictionary, a definition of the word "accident." You will get the point of what may seem to you right now to be merely another of my frequent digressions from the main theme, but if it be a digression I think you will nevertheless find it of interest. The word "accident" in Webster's Unabridged Dictionary is defined as follows:

> 1. Literally, a befalling;
>
> a. An event that takes place without one's foresight or expectation; an undesigned, sudden, and unexpected event.
>
> b. Hence, often, an undesigned and unforeseen occurence of an afflictive or unfortunate character; a mishap resulting in injury to a person or damage to a thing; a casualty; as, to die by an *accident*.

There are further definitions of the word but what I've given is sufficient for our purposes. But why define the word? What has it to do with COMSEC?

During our participation in World War II, the President of the United States, accompanied by many of his highest-level military, naval and civilian assistants, journeyed several times half-way around the world. He and they journeyed in safety—neither he nor they met with an "accident." Here's a picture taken at the Casablanca Conference in January 1943 (Fig. 103). Imagine the disaster it would have been if the plane carrying this distinguished group had been shot down and lost in the Atlantic or the Mediterranean. On the other hand, in April 1943, Admiral Isoroku Yamamoto, Commander-in-Chief of the Combined Fleet of the Japanese Imperial Navy started out on what was to be just an ordinary inspection trip but turned out to be a one-way trip for him. Here's a good picture of the Admiral (Fig. 104), who was the architect of the attack on Pearl Harbor. His death was announced in an official Japanese Navy communiqué stating that the Admiral "had met a glorious end while directing operations in a naval engagement against superior enemy forces." But we know that this was simply not true; Admiral Yamamoto "met with an accident." Some bright person—I think it was

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U.S. Navy Operations in the Pacific: "Coral Sea, Midway and Submarine Actions, May-August 1942." Little, Brown, New York: 1944, page 185. It is interesting to note that Adm. Morison, in an article entitled "Lessons of Pearl Harbor" published in the Saturday Evening Post, Oct. 28, 1961, concludes, "It was the setup at Washington and at Pearl, not individual stupidity, which confused what was going on. No one person knew the intelligence picture; no one person was responsible for the defense of Pearl Harbor; too many people assumed that others were taking precautions that they failed to take."

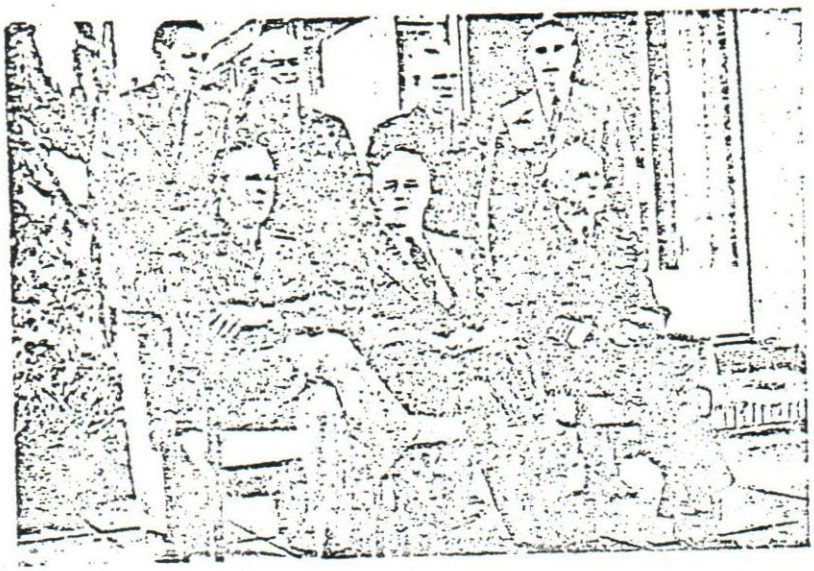

Figure 103.

Figure 104.

the late Jimmy Walker, when Mayor of New York City—has said that "accidents don't just happen—they are brought about." Jimmy Walker's comment was true in this case at least: Admiral Yamamoto did not die by accident; he died because our Navy knew the schedule of his trip down to the very last detail so that it was possible to set up an ambush with high degree of success. Here is the story as told in an interesting manner by Fleet Admiral William F. Halsey, U.S.N., in his book entitled *Admiral Halsey's Story*.[13]

> "I returned to Noumea in time to sit in on an operation that was smaller but extremely gratifying. The Navy's code experts had hit a jackpot; they had discovered that Admiral Isoroku Yamamoto, the Commander-in-Chief of the Imperial Japanese Navy, was about to visit the Solomons. In fact, he was due to arrive at Ballale Island, just south of Bougainville, precisely at 0945 on April 18. Yamamoto, who had conceived and proposed the Pearl Harbor attack, had also been widely quoted as saying that he was "looking forward to dictating peace in the White House at Washington." I believe that this statement was subsequently proved a canard, but we accepted its authenticity then, and it was an additional reason for his being No. 3 on my private list of public enemies, closely trailing Hirohito and Tojo.
>
> Eighteen P-38's of the Army's 339th Fighter Squadron, based at Henderson Field, were assigned to make the interception over Buin, 35 miles short of Ballale. Yamamoto's plane, a Betty, accompanied by another Betty and covered by six Zekes, hove in sight exactly on schedule, and Lt. Col. Thomas G. Lamphier, Jr., dove on it and shot it down in flames. The other Betty was also shot down for good measure, plus one of the Zekes . . We bottled up the story, of course. One obvious reason was that we didn't want the Japs to know that we had broken their code . . . Unfortunately, somebody took the story to Australia, whence it leaked into the papers, and no doubt eventually into Japan . . . But the Japs evidently did not realize the implication any more than did the tattletale; we continued to break their codes."

But lest you get the impression that enemy intelligence agencies had no success at all with secret communications of U.S. Armed Forces, let me tell you that they did have some success and in certain instances, very significant success. There is not time to go into this somewhat disillusioning statement, but I can say that as a general rule the successes were attributable not to technical weakness in U.S. cryptosystems but to their improper use in the case of certain low-level ones, by unskilled, and improperly or insufficiently trained cryptographic clerks. I may as well tell you right now that this weakness in cryptocommunications has been true for a great many years, for centuries as a matter of fact, because as long ago as the year 1605 Francis Bacon, who wrote the first treatise in English on the subject of cryptology, made the following comment:[14]

> "This Arte of *Cypheringe*, hath for Relative, an Art of *Discypheringe;* by supposition unprofitable; but, as things, are of great use. For suppose that Cyphars were well managed, there bee Multitudes of them which exclude the *Discypherer*. But in regarde of the rawnesse and unskillfulness of the handes, through which they passe, the greatest Matters, are many times carryed in the weakest *Cyphars*."

When electrical, particularly radio, transmission entered into the picture, additional hazards to communication security had to be taken into account, but many commanders failed to realize how much valuable intelligence can be obtained merely from a study of the procedures used in the transmission of messages as well as from a study of the direction and flow of radio traffic, the call signs of the transmitting and receiving stations, etc., all without solving the communications even if they were in cryptic form.
from a document entitled *German Operational Inte*

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[13] *Admiral Halsey's Story*. McGraw-Hill, New York, 1947, pp. 155–157.

[14] *The Two Bookes of the proficience and advancement of Learning*, London, 1605, p. 61. This book is commonly known as *The Advancement of Learning*. Some 18 years later Bacon saw no reason to change his comment in his *De Augmentis Scientiarum*, London 1623. In fact, he strengthened it by making it read: " . . . but the rawnesse and unskillfulnesse of Secretaries, and Clarks, in the Courts of Princes, is such that many times the greatest matters are committed to futile and weake Cyphers." (Gilbert Wats' translation, 1640, p. 270.)

Coming directly now to the history of the development of our cryptomaterials themselves, I hardly need reiterate what was pointed out in previous lectures as to the profound effect of the advances in the science and art of electrical communications in the 20th Century. Those advances had a direct effect upon military communications and an indirect effect upon military cryptology. Hand-operated ciphers and, of course, codebooks became almost obsolete because the need for greater and greater speed of cryptographic operations became obvious in order to match as much as possible the very great increase in the speed of communications brought about by inventions and improvements in electric wire and radiotelegraphy. The need for cryptographic apparatus and machines thus very soon became quite obvious, but it took quite some time to satisfy that need in a manner that could be considered to give adequate security for military communications.

The history of the invention and development of cryptographic devices, machines and associated apparatus and material is long and interesting. Let us begin with a résumé of the earliest items of importance in that history.

Until the advent of electronic cipher machines most cryptographic apparatus and devices were built upon or around concentric circular rotating members such as cipher wheels, cipher disks, etc. A very early, perhaps the earliest picture of such a device appears in a treatise by an Italian cryptologist named Alberti, whose *Trattati in Cifra* was written in Rome about 1470. It is the oldest tract on cryptography the world now possesses. Here's a photo of Alberti's disk (Fig. 105), but I won't take the time to explain it except to say that the digits 1, 2, 3, 4 were used to encipher code groups and to call your attention to the fact that the letters of the cipher or revolving alphabet were in mixed order. In Porta's book, first published in 1563 in Naples, there appear several cipher disks; in the copy which was given me as a gift by Colonel Fabyan, they are still in working condition. Here is a picture of one of them (Fig. 106). In this version the device uses symbols as cipher characters. And apparently nobody thought up anything much better for a long, long time. It seems, in fact, that not only did no one think up anything new or even some improvements on the original Alberti or Porta disks but those who did any thinking at all on the subject merely "invented" or "re-invented" the same thing again, and that happened repeatedly in successive generations. For instance, in Lecture No. IV of this series you were shown a picture of the cipher disk "invented" by Major Albert Myer, the first Chief Signal Officer of the U.S. Army, who obtained patent on his invention in 1865. Here's a picture of the patented disk (Fig. 107) and the explanation of the invention (Fig. 108). You may also remember that signalmen of the Confederate Signal Corps mechanized the old Vigenère Square and put it out in the form of a cylinder (see Figs. 65 and 66 of Lecture No. IV). The cipher disk used by the Signal Corps of the U.S. Army during the decade 1910 to 1920, that is, during the period including our par-

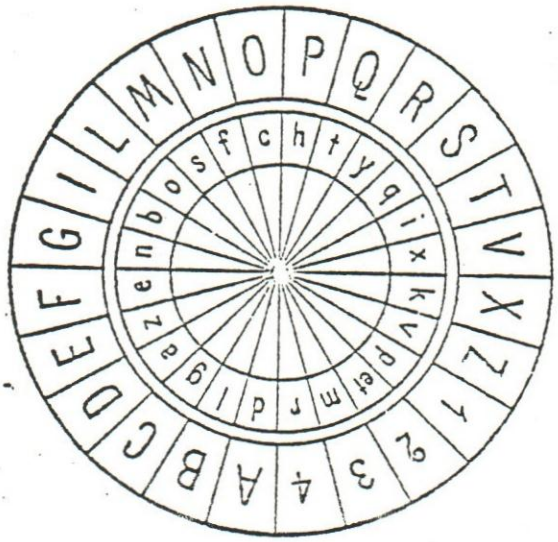


Figure 105.

Figure 106.

ticipation as a belligerent in World War I, was nothing but a white celluloid variation of the original Alberti parchment disk of the vintage of 1470 (except that it was even simpler than its progenitor, because in the latter the cipher alphabets produced were mixed alphabets whereas, in the Signal Corps disk, the cipher alphabets are simple reversed standard sequences (Fig. 109). We all know that it generally takes a pretty long time to get a patent through the U.S. Patent Office, but the ancient device was patented in 1924 by S. H. Huntington (Fig. 110): here you can see a great improvement over the Signal Corps version—a blank is added to both sequences so that the space between words could be enciphered. Indication of word space, as you have learned, is a fatal weakness if seen in the cipher text; in the Huntington device the spaces between words would be enciphered but the cipher text would have space signs, although they would not correspond to the actual spaces between words in the plain text. In the Huntington device, the space signs in the cipher text would be a bit misleading but not to an experienced cryptanalyst, who would soon realize that they do not actually represent "word space" in the plain text.

It is interesting to note that in 1936, during the days when the German National Socialists were banned as an organization in Austria, the Nazis used this variation of the old disk—it had 10 digits on both the outer and the inner sequences for enciphering digits (Fig. 111).

The first significant improvement on the old cipher disk was that made by Sir Charles Wheatstone, in 1867, when he invented a cipher device which he called *The Cryptograph*. He described it in a volume entitled *The Scientific Papers of Sir Charles Wheatstone*, published in 1879 by the Physical Society of London. Here is a picture of the Wheatstone device in my private collection (Fig. 112). What Sir Charles did was to make the outer circle of letters (for the plain text) comprise the 26 letters of the alphabet, plus one additional character to represent "space." The inner circle, for cipher equivalents, contains only the 26 letters of the alphabet, and these can be disarranged in a mixed sequence. Two hands, like the hour and minute hands of a clock, were provided and they are under control of a differential gear mechanism, so that when the long or "minute hand" is advanced to make a complete circuit of the letters on the outer circle the short or "hour hand" advances one space or segment on the inner circle. In Fig. 112, for example, the plaintext letter *G* is represented by the cipher letter *A*, that is, $G_p = A_c$. If the long hand is now advanced in a clockwise direction for one revolution, G_p will be represented no longer by A_c but by G_c, the letter immediately to the right of A_c on the inner circle. In encipherment the long hand is always moved in the same direction (clockwise, for example), and its aperture is placed successively over the letters on the

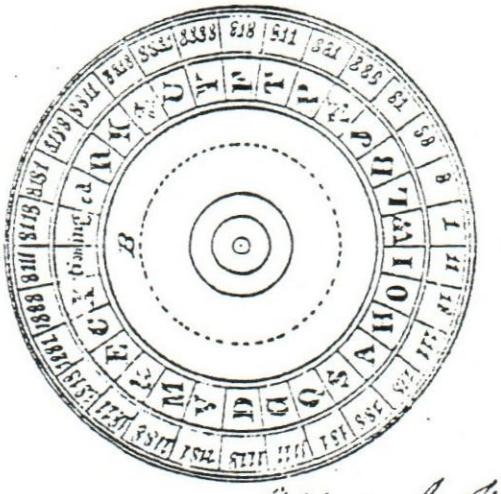
A. J. Myer,

Reading Signals.

No. 50,946. Patented Nov. 14, 1865.

Fig 2.

Fig 1.



Witnesses.
R. F. Campbell.
Edw. Schuyler

Inventor.
Albert J. Myer
by his Attys
Marcus Bruce & Sumner

Figure 107.

UNITED STATES PATENT OFFICE.

ALBERT J. MYER, OF WASHINGTON, DISTRICT OF COLUMBIA.

IMPROVEMENT IN SIGNALS.

Specification forming part of Letters Patent No. 50,946, dated November 14, 1865.

To all whom it may concern:

Be it known that I, ALBERT J. MYER, of Washington city, District of Columbia, have invented a new Mode of Communicating by Signals; and I do hereby declare that the following is a full, clear, and exact description thereof, reference being had to the accompanying drawings, making a part of this specification, in which—

Figure 1 is a front view of two disks having certain characters upon them to be used in communicating by signals. Fig. 2 is a diametrical section through the disks, showing the manner of attaching them together.

The object of this invention is to afford means whereby persons within signal distance of each other can communicate intelligibly by certain movements of flags or other objects, and a systematic arrangement of letters and numerals or other characters upon movable and stationary disks, without the possibility of having their messages detected by others.

To enable others skilled in the art to understand my invention I will describe my improved method of signaling.

In the accompanying drawings, A represents a disk having printed or engraved upon it in any sequence certain figures or characters, which indicate signals to be made or characters or words to be written. B is a smaller disk having upon it the letters of an alphabet in any desired sequence, which it may be desired to refer to in signaling. These two disks are pivoted together centrally by means of a clamp-screw, on loosening which the smaller disk may be turned in either direction, so as to bring different letters opposite to the numerals, after which, by tightening the screw *a*, the disks will be rigidly connected together.

Each person giving and receiving signals should be provided with one of these devices, and there should be a preconcerted understanding between such persons for moving the disk B and causing different signal combinations to stand at different times for different letters or messages, for the purpose of concealing the meaning of the signals.

The mode of signaling is as follows: Suppose two persons within signal distance of each other should desire to communicate the word "are," and by preconcerted signals have both adjusted their disks so that the letter A shall be opposite to the number 11. Now, to spell the word "are" the signals designated by the combination "11" for "A" are made, and this will indicate to the observer the letter "A." Then there should be made the signal indicated by the figures "8111" or "R," and this would indicate to the observer this letter. The signal or signals indicating the letter "E," which are "1181" on the disk, conclude the word are.

It may be desirable for purposes of concealment that the word "are," though often occurring, should not again be indicated in the same communication by the same signals. In this case let it be understood by preconcert that upon any given signal, such as the dropping of a flag or some peculiar wave of a flag, the smaller disk, or that which has upon it the letters of the alphabet, is to be moved upon the largest disk, or that which has upon it the numerals, turning to the right hand, say, the distance of four spaces, marked upon the disk. Now, without cessation of signaling, both persons, the transmitter and the receiver, would upon this signal each so change the position of the disks that in again signaling the word "are" "A" would stand opposite to and be designated by the combination "188," "R" would be designated by the combination "1188," and "E" by "1881." The letters "A R E" or the word "are" thus signaled would in no way resemble the same word before sent. In this way it can be so arranged by preconcerting that no word shall appear twice in the same manner in the same message.

There may be several disks joined together, having various figures and characters upon them, and by preconcert it may be understood that in certain messages some of them are to be used and not others, or there may be more than one row of figures or characters on any of the disks and the preconcerted arrangement for using may be changed infinitely, so that the uninstructed cannot discover in what manner the disks are to be moved or used.

Having thus described my invention, what I claim as new, and desire to secure by Letters Patent, is—

The within-described system of signaling, which is controlled by means of letters, numerals, or other characters upon disks that are put together in such manner that the relative positions of such characters can be changed at pleasure, substantially as set forth.

ALBERT J. MYER.

Witnesses:
R. T. CAMPBELL,
E. SCHAFER.

Figure 108.

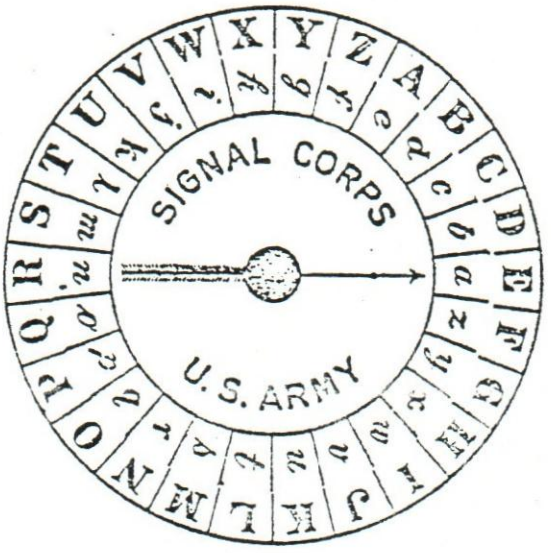


Figure 109.

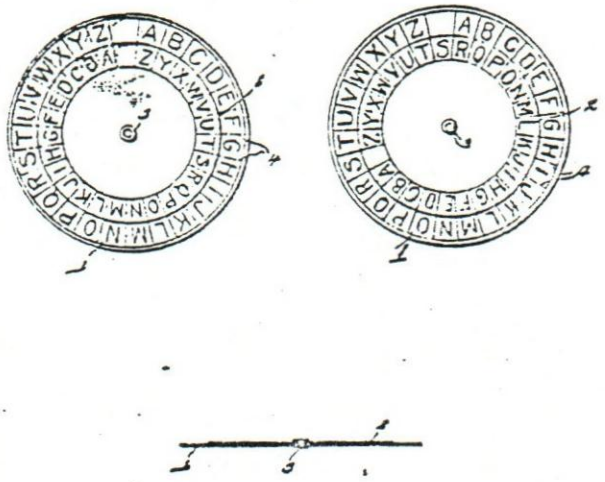


Figure 110.

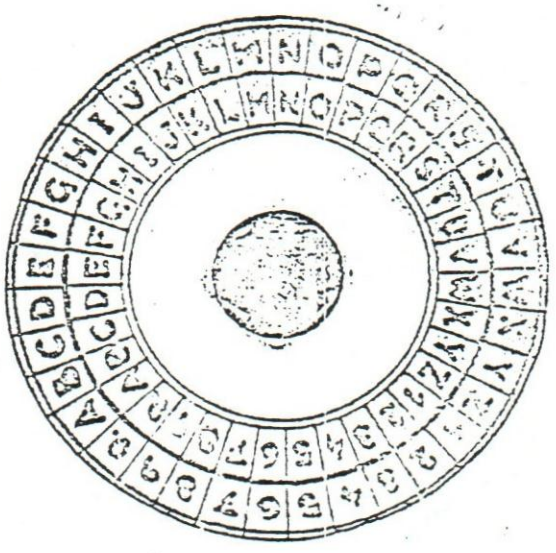


Figure 111.

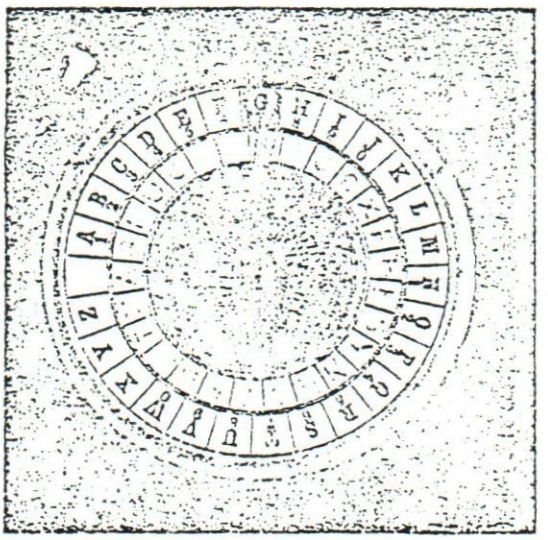


Figure 112.

outer circle according to the successive letters of the plaintext message, the cipher equivalents being recorded by hand to correspond with the letters to which the short hand points on each encipherment. In this way, identical letters of the plain text will be represented by different and varying letters in the cipher text, depending upon how many revolutions of the long hand intervene between the first and subsequent appearances of the same plaintext letter. Thus, with the alphabets shown in Fig. 112, and with the initial setting $G_p = A_c$, the word "reference" would be represented in cipher as follows: REFERENCE / XZZZBGQAM, in which it will be seen that repeated letters in the plain text are represented by different letters in the cipher text. Correspondents must naturally agree upon the mixed alphabet used in the inner circle and the initial positions of the two hands at the beginning of the encipherment of a message. In decipherment, the operator moves the long hand again clockwise, until the hour hand points to the cipher letter in the plaintext letter which is seen through the aperture at the end of the long hand on the outer circle. Thus, in the case of the example given above the cipher letters XZAABGQAM will be found to represent the word REFERENCE.

During World War I, some time in 1917, the British Army resuscitated Wheatstone's cryptograph and improved it both mechanically and cryptographically. Here's a picture of the device (Fig. 113), in which it will be seen that there are now no longer the "minute" and "hour" hands but a single hand with an opening or window that simultaneously discloses both the plain and the cipher letters. When the single hand is turned, the inner circle of segments, which are made of a substance upon which letters may be written in pencil or in ink is advanced eccentrically and against a similarly-made outer circle of segments. In this improvement on the original Wheatstone device both sequences of letters are now mixed sequences. Making the outer circle also a mixed sequence added a considerable degree of security to the cipher. When it was proposed that all the Allied armies use this device for field cryptocommunications and its security had been approved by British, French, and American cryptologists (both at GHQ-AEF and at Washington), an opportunity to agree or disagree with the assessment of these cryptologists was given me while still at Riverbank. I was able to show that the modified Wheatstone cryptograph was still insufficiently secure for military purposes,

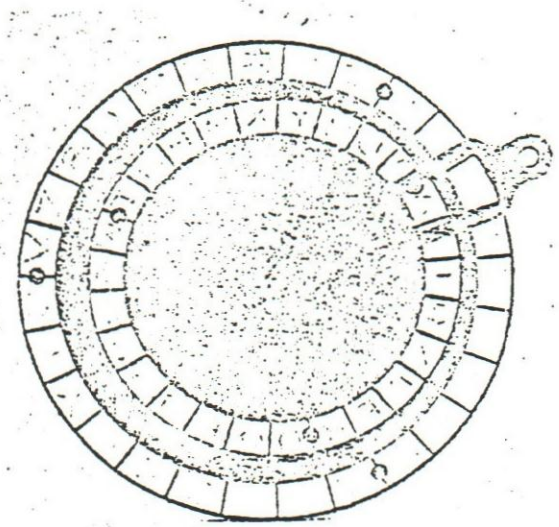


Figure 113.

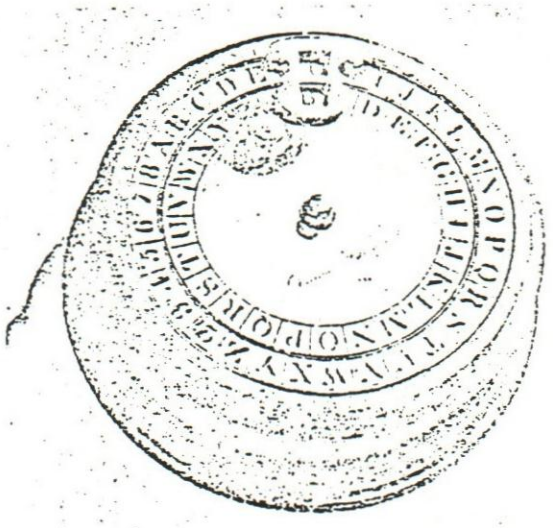


Figure 114.

d the devices, thousands of which had been manufactured and issued, were withdrawn. If you are interested in the method of solution, I used you will find it in Riverbank Publication No. 20, entitled *Several Machine Ciphers and Methods for their Solution* (1918). A better method of solution was devised by me about 1923.

Some years later, and almost by sheer good fortune, I learned that a cipher machine was in the museum of a small town in Connecticut named Hamden. I was interested and wrote to the curator of the museum, requesting that he lend the device for a short period to me as principal cryptanalyst of the War Department. Imagine my astonishment and pleasure when I unpacked the box upon its receipt and found a device, beautifully made and encased in a fine mahogany case, with its inventor's name, Decius Wadsworth, and the date, 1817, engraved on the face of the machine, which was nothing but another version of the Wheatstone Cryptograph. Here's a picture of it (Fig. 114). There are good reasons to believe that the model was made by Eli Whitney. Mechanically it was similar to the British modification, except that the outer sequence had 33 characters, the inner 26, so that the differential gear instead of operating on the ratio of 27 to 26 was now on the ratio 33 to 26. Thus, Colonel Decius Wadsworth, who was then the first Chief of Ordnance of the U.S. Army, had anticipated Wheatstone by over 60 years in this invention. He also anticipated the British Army cryptologists of World War I by a whole century in their modification of Wheatstone's original, because in the Wadsworth device, too, there was only one hand and both alphabets could be made mixed sequences. This is very clearly shown in Fig. 115 as regards the outer sequence, and I believe the inner one could also be disarranged, but the picture does not clearly show this to be the case, so that I am not sure as to this point. I returned the device a good many years ago, and it is now on display in the Eli Whitney Room of the New Haven Historical Society's Museum.

The next device I bring to your attention is shown in Fig. 116, a device invented by a French army reservist, Commandant Bazeries, who for some 10 years valiantly but unsuccessfully tried to get the French Army to adopt it. He included a description of his device, which he called his "Cryptographe Cylindrique" or "cylindrical cryptograph," in a book published in

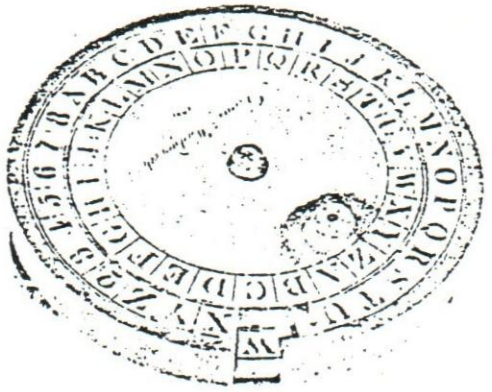


Figure 115.

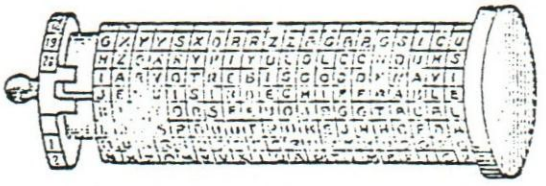


Figure 116.

1901 in Paris.[15] He had, however, previously described his device in an article entitled "Cryptographe à 20 rondelles—alphabets (25 lettres par alphabet)," published in 1891.[16] In this device there is a central shaft on which can be mounted 20 numbered disks on the peripheries of which are differently mixed alphabets of 25 letters each. The disks can be assembled in some prearranged or key sequence on the shaft, from left to right, but they can be revolved thereon and then locked into position on the shaft by pushing in the locking disk at the extreme left. The first 20 letters of the plain text of a message are first aligned, as seen in Fig. 116 (JE SUIS INDÉCHIFFRABLE = "I am indecipherable"); the disks are then locked into position so that the whole assemby can be turned; and as cipher text one may select any one of the other 24 rows of letters, which are recorded then by hand on paper. Then the next 20 plaintext letters are aligned, one of the other 24 rows of letters selected and recorded, etc. To decipher a message, the disks having been assembled on the shaft in accordance with the prearranged or key sequence, one takes the first 20 cipher letters, aligns and then locks them into position, and then turns the whole cylinder, searching for a row of letters which form intelligible text. There will be one and only one such row, and the plaintext letters are recorded. Then the next 20 letters of cipher are aligned, etc.

Another French cryptologist, the Marquis de Viaris, soon showed how messages prepared by means of the Bazeries cylindrical cipher could be solved.[17] Maybe that is why Bazeries wasn't too successful in his attempt to get the French Army to adopt his device. But in the U.S. there were apparently none who encountered either what Bazeries or de Viaris wrote on the subject. Capt. Parker Hitt, U.S. Army, whom I have mentioned in a previous lecture, in 1915 invented a device based upon the Bazeries principle but not in the form of disks mounted upon a central shaft. Instead of disks, Hitt's device used sliding strips and here is a picture of his very first model (Fig. 117), which he presented to me some time in 1923 or 1924. But I first learned about his device some time in 1917 while still at Riverbank and solved one challenge message put up by Mrs. Hitt, a Riverbank guest for a day. In meeting the challenge successfully (which brought a box of chocolates for Mrs. Friedman from Mrs. Hitt) I didn't use anything like what I could or might have learned from de Viaris, because at that time I hadn't yet come across the de Viaris book. I solved the message by guessing the key Mrs. Hitt employed to arrange her strip alphabets. She wasn't wise to the quirks of inexperienced cryptographic clerks; she used RIVERBANK LABORATORIES as the key, just as I suspected she would. The device she brought with her was an improved model: the alphabets were on paper strips and the latter were glued to strips of wood, as seen in Fig. 118.

Capt. Hitt brought his device to the attention of the then Major Mauborgne, whom I have also mentioned in a previous lecture and who was then on duty in the Office of the Chief Signal Officer in Washington. There is some question as to whether it was Hitt who first brought his device to Mauborgne's attention; Mauborgne later told me that he had independently conceived the invention and, moreover, had made a model using disks instead of strips. I have that model, a present from General Mauborgne many years later. It is made of very heavy brass disks on the peripheries of which he had engraved the letters of his own specially-devised alphabets. In 1919, after my return to Riverbank from my service in the AEF, Mauborgne sent Riverbank the beginnings (the first 25 letters) of a set of 25 messages enciphered by his device and alphabets. He also sent the same data to Major Yardley, in G-2. Nobody ever solved the messages, even after a good deal of work and even after Mauborgne told us that two consecutive words in one of the challenge messages were the words "are you." Many years later I found the reason for our complete lack of success, when I came across the plain texts of those messages in a dusty old file in one of the rooms occupied in the old Munitions Building by the Office of Chief Signal Officer. Here is a picture of the beginnings of the first six messages (Fig. 119). Mauborgne, when I chided him in the unfairness of his challenge

[15] *Les Chiffres secrets dévoilés.*

[16] *Comptes Rendus*, Marseilles, Vol. XX pp. 160–165.

[17] *L'art de chiffrer et de déchiffrer les dépêches secrètes*, Paris, 1893, p. 100.

Figure 117.

messages, told me that he had not prepared them himself—he had an underling (Major Fowler was his name, I still remember it!) prepare them. In our struggles to solve the challenge messages we had assumed that they would contain the usual sorts of words found as initial words of military messages. It was the complete failure by Riverbank and G–2 to solve the challenge messages that induced Mauborgne to go ahead with the development of his device. It culminated in what became known as Cipher Device, Type M–94. Here is a picture of it (Fig. 120). That device was standardized and used for at least 10 years in the U.S. by the Army, the Navy, the Marine Corps, the Coast Guard, the Intelligence Agencies of the Treasury Department, and perhaps by other agencies.

In 1922, a wartime colleague, the late Capt. John M. Manly (Professor and Head of the Department of English at the University of Chicago) brought to my attention a photostat of two pages of a holographic manuscript in the large collection of *Jefferson Papers* in the Library of Congress. It described his invention entitled "The Wheel Cypher," and here is a picture of the second page (Fig. 121) showing Jefferson's basis for calculating the number of permuta-

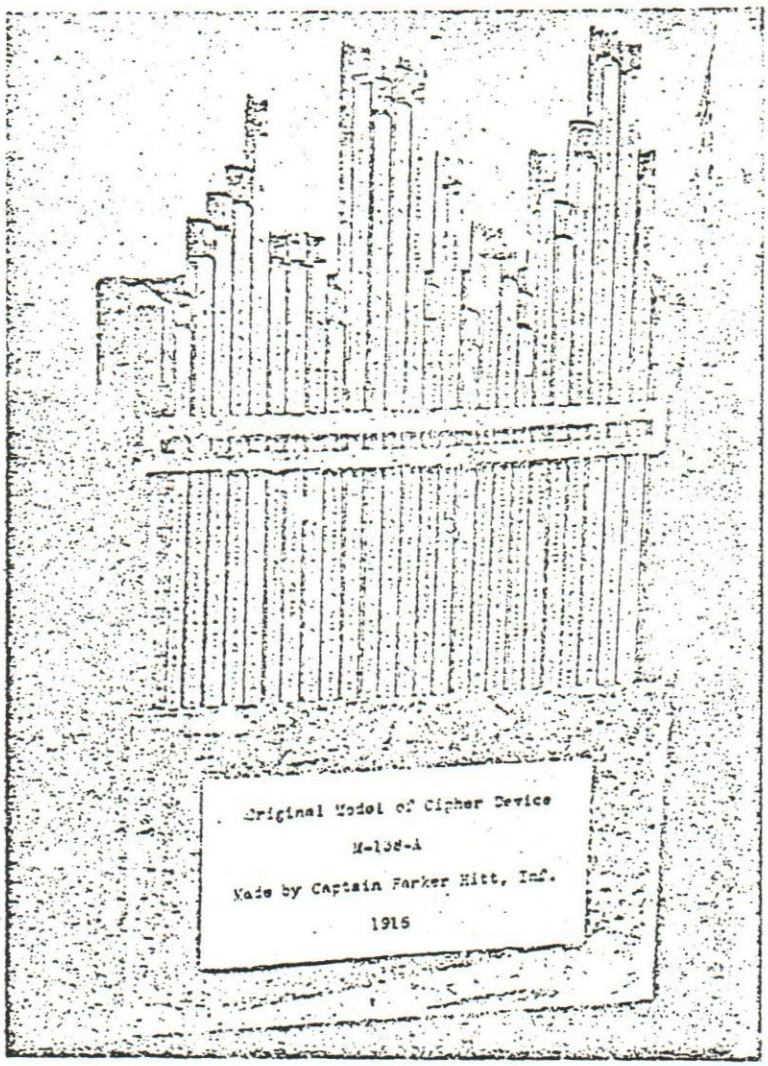


Figure 118.

Phenols are benzene derivati
YQWRM|IHDHB|RQBWVIL|KJCS|KEYUU
Xylonite and artificial ivory
SSEIQ|DWHNH|QHGIK|HAADN|GNFBY
I went to a new theatre the Pala
YXDVX|NIGJO|PCOTN|GKWAX|YTNWL
Picric acid is explosive and I
QJRLH|AWTWU|CYXYM|BGJCR|SBHWF
Llangollen is a town in Wales a
DULPK|UXMVL|XFUPS|ULRZK|PDALY
Yuelle are for rice shopping
DCAIY|LUPMB|NACQE|OPTLH|KKRGT

Figure 119.

tions afforded by the set of 36 wheels of his device. He didn't attempt to make the multiplication; he didn't have an electronic digital computer— for the total number is astronomical in size. Jefferson anticipated Bazeries by over a century, and the Hitt-Mauborgne combination by almost a century and a half.

Figure 120.

It soon became apparent to both Army and Navy cryptologists that a great increase in cryptosecurity would be obtained if the alphabets of the M-94 device could be made variant instead of invariant. There began efforts in both services to develop a practical instrument based upon this principle. I won't take time to show all these developments but only the final form of the one adopted by the Army, Strip Cipher Device Type, M-138-A (Fig. 122). This form used an aluminum base into which channels with overhanging edges were cut to hold cardboard strips of alphabets which could be slid easily within the channels. It may be of interest to you to learn that after I had given up in my attempts to find a firm which would or could make such aluminum grooved devices in quantity, Mrs. Friedman, by womanly wiles and cajolery on behalf of her own group in the U.S. Coast Guard, succeeded in inducing or enticing one firm to make them for her. And that's how the first models of strip cipher devices made of aluminum by the extrusion process came about, and how the U.S. Army, by administrative cooperation on an inter-Service level and technical cooperation on a marital level, found practical to develop and produce in quantity its Strip Cipher Device, Type M-138-A. This was used from 1935 to 1941 or 1942 by the Army, the Navy, the Marine Corps, the Coast

Guard, et al, including the Treasury and State Departments. It was used as a back-up system even after the Armed Services as well as the Department of State began employing much better and more sophisticated cipher machines of high speed and security.

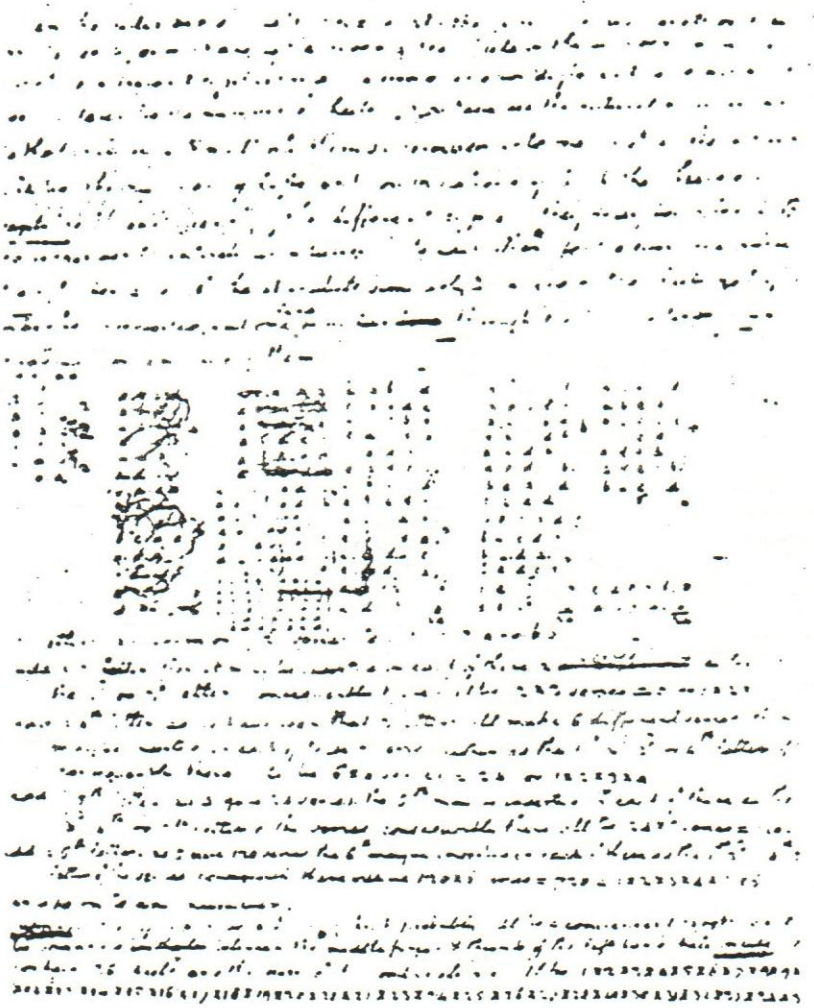


Figure 121.

Thus far we have been dealing with cipher devices of the so-called "hand-operated" type. None of them can readily be considered as being "machines," that is, apparatus employing mechanically driven members upon which alphabetic sequences can be mounted so that constantly changing sequences of cipher alphabets are produced. We come now to types of apparatus which can be called *machines*, and one such machine is shown in Fig. 122. It is called the Kryha machine, after the name of its German inventor, who unfortunately committed suicide a few years ago, perhaps because the last model of his improved machine failed to impress professional cryptologists. The Kryha has a fixed semicircle of letters against which is juxtaposed a rotatable circle of letters. Both sequences of letters can be made mixed alphabets (the segments are removable and interchangeable on each sequence). The handle at the right serves to wind a rather powerful steel clock spring which drives the rotatable platform on which the letters of the inner circle are mounted. In Fig. 124 can be seen something of

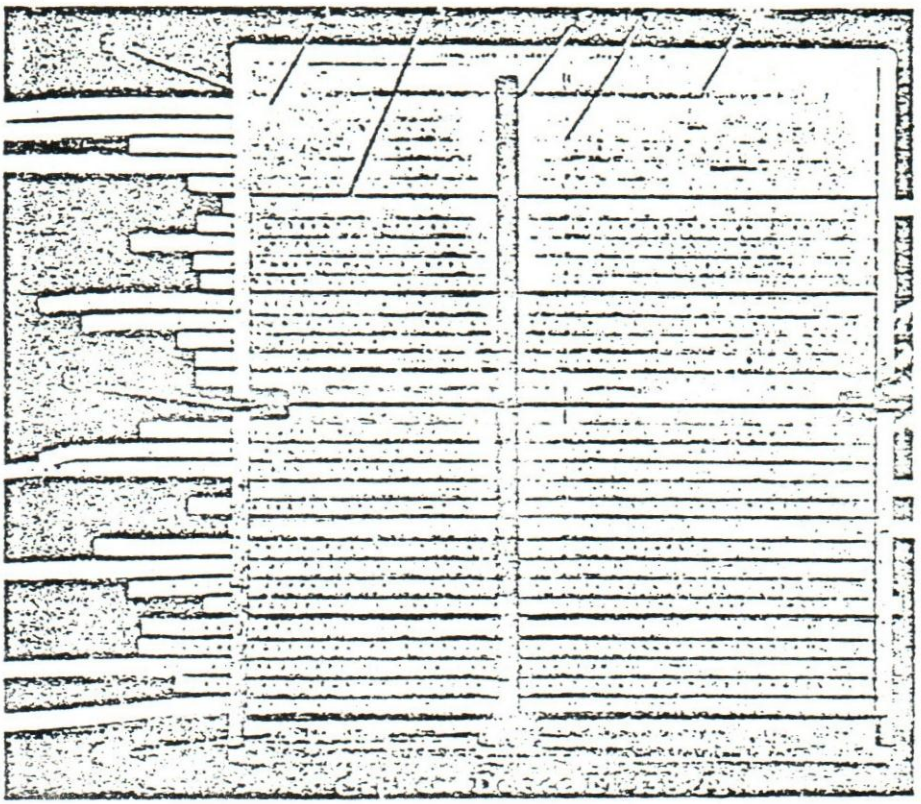


Figure 122.

the inner mechanism. The large wheel at the right has segments which are open or closed, depending upon the "setting" or key. This wheel controls the angular displacement or "stepping" of the circular rotatable platform. The initial juxtaposition of the inner or movable alphabet against the outer or fixed one, as well as the compostion of these alphabets, is governed by some key or other prearrangement. The cipher equivalents must be recorded by hand. After each encipherment, the button you saw in the center of the panel in Fig. 123 is pushed down, the inner wheel is advanced 1, 2, 3, 4 . . . steps, depending on the key, and the next letter is enciphered, etc. The pictures I've shown you apply to the latest model of the Kryha; as regards the first model, which came on the market sometime in the 1920's, a German mathematician produced an impressive brochure showing how many different permutations and combinations the machine afforded. Here's a picture of a couple or pages of his dissertation, (Fig. 125) but even in those days professional cryptanalysts were not too impressed by calculations of this sort. With modern electronic computers such calculations have become of even less significance.

With the introduction of printing telegraph or teleprinting machines for electrical communications, the need became pressing for a reliable and practical cryptographic mechanism to be associated or integrated with such machines. The first apparatus of this sort in the U.S., shown in this photo (Fig. 141), was that developed by the American Telephone and Telegraph Co., in 1918, as a more-or-less simple but ingenious modification of its ordinary printing telegraph. First, a few explanatory words about the basic principles of the modern teleprinter may be useful. This principle employs what is called the "Baudot Code," that is, a system in which permutations of two different elements taken in groups of five are employed to represent characters of the alphabet. Curiously enough, Francis Bacon was the first to employ such a "code" way back in the early 17th Century, and I showed you the one he used in Lecture No. II (see Fig. 31 on p. 34). These two elements in Bacon's "code" were *a*'s and *b*'s; he used but 24 of the 32 permutations available ($2^5 = 32$). For electrical communications the two elements may be positive and negative currents of electricity, or the presence and absence of current, the latter system being often referred to as being composed of "marking" and "spacing" elements, respectively. The illustration below (Fig. 142) depicts the Baudot or "5-unit code" in the form of a paper tape in which there are holes in certain positions transverse to the length

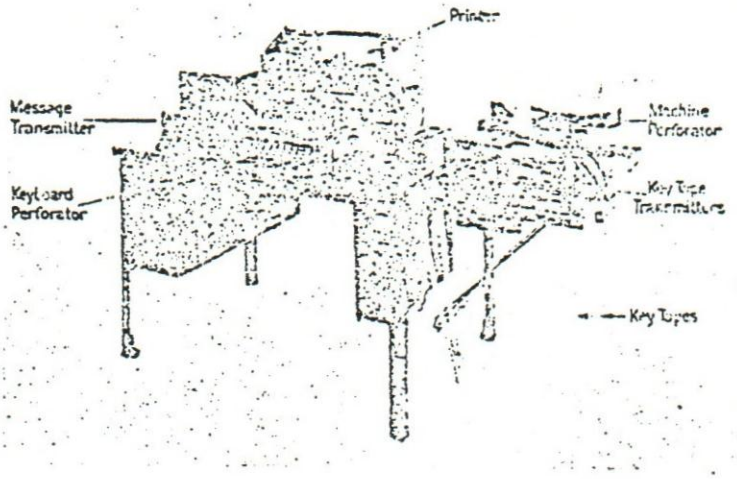
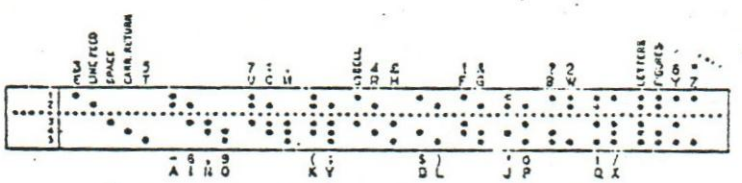


Figure 141.



TAPE SHOWING PRINTING TELEGRAPHIC CODE

Figure 142.

of the tape. The holes are produced by a perforating mechanism; the small holes running the length of the tape are "feed-holes" by means of which the tape is advanced step by step. You will note that there are five levels on which the perforations appear. The letter *A*, for example, is represented by a perforation only on the 1st and 2nd levels, the 3rd, 4th and 5th levels remaining unperforated; the letter *I* is represented by holes in positions 2 and 3, no holes on the other three levels, etc. The English alphabet uses 26 of the 32 permutations; the remaining 6 permutations are used to represent the so-called "stunt characters," which I will now explain. The third and fourth characters from the right-hand end of the tape are two permutations labeled "letters" and "figures," respectively. These are equivalent to the "shift" and "unshift" keys on a typewriter keyboard, for "lower" and "upper" case. When the "letters" key is depressed, the characters printed are the 26 letters of the alphabet (all capital letters); when the "figures" key is depressed the characters represented are similar to those printed on a typewriter when the "shift" key is depressed. The second, third, and fourth permutations at the left-hand end of the tape are also stunt characters and represent "line feed," "space," and "carriage return," and they perform electrically in a teleprinter what is done by hand on a typewriter: "line feed" causes the paper on which the message is printed to advance to the next line; "space" does exactly what depressing the space bar on a typewriter does, etc. When there are no holes anywhere across the tape, the character is called a "blank" or "idling" character—nothing happens; the printer does no printing, nor is there any "stunt" functioning by the printer, but the tape merely advances.

Modifying the standard printing telegraph machine to make it a printing telegraph cipher machine, to put the matter in a slightly different way, in developing the printing telegraph cipher machine the American Telephone and Telegraph Company was fortunate in having at its disposal the services of a 23-year old communications engineer named Gilbert S. Vernam, (Fig. 143) who conceived a brilliant principle and an automatic method for enciphering tele-

printer communications. The principle and method turned out to be so useful and valuable, not only in the U.S. but also internationally, that it has come to bear his name and is often referred to as the "Vernam principle," the "Vernam rule," the "Vernam mod-2 addition," etc. Vernam saw that if in accordance with some general but invariant rule the marking and spacing elements of a 5-unit code group were combined one by one with those of another 5-unit code group, which would serve as a keying group, and the resultant 5-unit group transmitted over a circuit and combined at the receiver with the same keying group in accordance with the same general rule,[18] the final resultant would be the original character. Vernam conceived the idea early in 1918, or perhaps in late 1917. I have a copy of Vernam's circuit diagram, dated and witnessed on 27 Feb 1918, but the application for a patent thereon, with his name as inventor, was filed in the U.S. Patent Office on 13 September 1918, and Patent No. 1,310,719 was granted on 22 July 1919, covering the invention entitled a "Secret Signaling System."

The following more detailed description of Vernam's patent on the foregoing cipher system is extracted from a paper[19] written by one of the A. T. & T. Company's engineers who was associated with Mr. Vernam at the time the invention was conceived and who, a few years after retirement from that company, became one of NSA's consultants:

> "This patent describes an "on-line" system, each character being enciphered, immediately transmitted, and in turn deciphered without delay at the receiving terminal. Thus, characters of a message in perforated tape form are automatically combined with other or key characters which are transmitted over the circuit. At the receiver an identical group of key characters is used to provide signals for combination with the arriving signals, character by character, to produce the original message. The combining rule for these operations disclosed in the patent was one in which like code elements produced "spaces" and unlike elements, "marks," as shown below.
>
> The cipher message tape prepared in this way is unintelligible in form and may be sent to the receiving station by messenger or by mail, or if desired, it may be transmitted by wire or radio and reproduced by another machine perforator at the receiving point. The cipher tape is there run through the message transmitter, where its characters combine with those of a duplicate key tape to reproduce the original message, which will be printed out in page form and in "plain text."
>
> LENGTH OF KEY TAPE
>
> With the system as described above, the key tape must be at least as long as the sum of all the message tapes used with it, as the messages will lose their secrecy to some extent if the key tape is used repeatedly. The use of a short repeating key may give sufficient secrecy for some uses, however.
>
> A roll of tape 8 inches in diameter contains about 900 feet of tape and would serve to encipher about 18,000 words counting five printed characters and a space per word, without repeating the key. If sent at an average speed of 45 words per minute, this number of words would require 400 minutes or nearly 7 hours to transmit.
>
> In order to reduce the amount of key tape required for handling large amounts of traffic, the "double key" system was devised.[20] In this system two key tapes are used, the ends of each tape being glued together to form a loop preferably about seven feet in circumference. The tapes should differ in length by one character or by some number which is not a factor of the number of characters in either tape. A separate transmitter is used for each tape, and the characters of the two key tapes are combined, by a method similar to that shown in Figure 144, with those of the message tape to form the cipher message.
>
> The result is the same as though the two key tapes were first combined to produce a long single non-repeating key, which was later combined with the message tape. This long, single key is not, strictly speaking, a purely random key throughout its length as it is made up of combinations of the two original and comparatively short key tapes. The characters in this key do not

[18] In this system which uses only two different symbols or elements, the so-called "binary code," the combining rule is its own inverse.

[19] Parker, R. D. "Recollections Concerning the Birth of One-Time Tape and Printing-Telegraph Machine Cryptography." *NSA Technical Journal*, Vol. I, No. 2, July 1956, pp. 103-114.

[20] By L. F. Morehouse, an A.T. & T. Company equipment engineer. See U.S. Patent No. 1,356,546, "Ciphering System," granted 26 October 1920—WFF.

Figure 143.

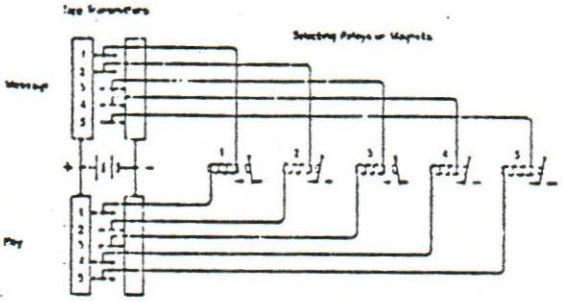


Figure 144.

repeat in the same sequence at comparatively short regular intervals, however, as would be the case if only one key tape loop were used.

The number of characters in this equivalent single key is equal to the product of the number of characters in the two tape loops, and may easily exceed 600,000 before any part of the key begins to repeat. If proper care is taken to use the system so as to avoid giving information to the enemy regarding the lengths of the two key tape loops or their initial settings and to avoid the possibility of ever re-using any part of the resultant single key, this system is extremely difficult to break even by an expert cryptanalyst having a large number of messages and full knowledge of the construction of the machine and its method of operation."

The foregoing double-key-tape system was placed into operation in 1918, on three start-stop circuits which were used for intercommunication among four stations serving Washington, New York, Hoboken and Norfolk, and which according to Parker [see footnote 20 above,] "continued in operation for many months, even after the end of the war." In addition, a Signal Corps Company was organized to go to Europe with new equipment for installation of printing-telegraph circuits in France. This Signal Company was about ready to sail when the Armistice was signed November 11, 1918.

Upon my return to Riverbank in April 1919, after being demobilized, I became an interested party in a rather warm argument conducted by letters exchanged between Colonel Fabyan, the Chief Signal Officer, the Director of Military Intelligence, and the War Department, regarding the cryptosecurity of the cipher printing telegraph system as used by the Signal Corps. The argument ended by successfully meeting a challenge by the Signal Corps to prove Fabyan's contention. The challenge consisted in sending Fabyan, on 6 October 1919, and requesting him to solve, the cipher tapes of about 150 messages selected from one day's traffic in the system. On 8 December 1919 Fabyan sent a telegram to the Chief Signal Officer notifying him that solution had been accomplished. In order to prove that this was true, I sent a perforated cipher-message tape to each of the officers named above. In order to decipher these messages the Chief Signal Officer had to use his own key tapes, thus proving that not only had Riverbank solved the system but had recovered both key tapes which had been employed in enciphering the challenge messages, so that Riverbank was in a position to produce the plain text of any of the latter on request, if further proof of solution was needed or desired. I wrote a monograph on the solution, consisting of a basic paper of 21 typewritten pages, an Addendum 1 of 10 pages, an Addendum 2 of 25 pages and an Addendum 3 of six pages; a copy of each of the documents was sent to Washington. The solution was accepted with mixed feelings in Washington, especially on the part of Brigadier General Marlborough Churchill, the Director of Military Intelligence, who had signed a letter to the Chief Signal Officer, dated 8 August

1918 prepared by Capt. Yardley to the effect that the cipher system in question "is considered by this office to be absolutely indecipherable."[21] General Churchill had the duty and courtesy to write a congratulatory letter to Colonel Fabyan, dated 24 March 1920, the final paragraph of which is as follows:

> "Your very brilliant scientific achievement reflects great credit upon you and your whole personnel. It would be impossible to exaggerate in paying you and Riverbank the deserved tribute for this very scholarly accomplishment."

The paper by Mr. Parker (see footnote 20) closes with the following final paragraph:

> "Perhaps some day Mr. Friedman will tell of the part that he and the Riverbank Laboratories played in the cryptanalytic phase of this development."

Mr. Parker was not aware of the fact that what he suggested had not only been done once, but twice. The first time was immediately after the solution when copies of the writeup mentioned a moment ago on page 101 had been sent to Washington where they had met the fate that often happens to documents of limited or special technical interest—complete disappearance in the voluminous files of bureaucracy. The second time was soon after the end of hostilities of World War II, when it was discovered that a certain outfit I won't name was using the double-tape keying system for its teleprinter communications. I rummaged through my own files and uncovered the handwritten manuscript of certain parts of what I had written at the close of the successful solution of that system while at Riverbank. My second write-up is a classified document, dated 21 July 1948, the subtitle of which is "Can Cryptologic History Repeat Itself?" It is possible that this write-up can be made available to those of you who are interested in reading it, if proper authority grants permission.

Mr. Parker's paper (see footnote 20, above) devotes a good deal of space to the contention that the only reason why the double-tape keying method was adopted was that the Signal Corps and specifically its representative, Colonel Mauborgne, "complained about the difficulties that might be experienced in the preparation and distribution of one-time random key tapes and seemed inclined to disapprove of the proposed system because of these difficulties. Since the system, when properly used, seemed obviously to be one which gave absolute secrecy, a discussion arose on the value of the system and on methods which might be devised for the production and distribution of long one-time key tapes having characters arranged at random." Parker points out that the original method of use contemplated the use of long tapes of this nature and that he and his associates felt that the problem of producing and distributing long tapes "while presenting a challenge, was not impractical." I am glad to admit that they were right, because during World War II and for years afterward tapes of this nature were produced by special machinery (in some cases as many as five copies being perforated and the sections numbered automatically in a single operation). Distribution of and accounting for the tapes proved practical, too, and aside from an occasional error involving the re-use of a once used tape, absolutely secure intercommunication by radio printing telegraphy was assured and was used between and among large headquarters where the volume of traffic justified the use of this equipment. The principal advantage was the simplicity of crypto-operations—no rotors to be set, no setup of rotors to be enciphered, no checking of encipherment by deciphering the message before transmission, etc.

The A. T. & T. Company Printing Telegraph Cipher equipments purchased by the Signal Corps were withdrawn soon after Riverbank proved the double-key-tape system insecure. The machines went into storage, when in due course most of them were dismantled. But after I left Riverbank at the end of 1920 and had joined the Chief Signal Officer's staff in

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[21] The letter consisting of a single paragraph stated: "1. The mechanical means of enciphering messages with an arbitrary, meaningless running key of 999,000 letters, provided no two messages are enciphered at the same point on the tape as explained to Major Mauborgne, Signal Corps, and Captain Yardley, Military Intelligence Branch, by officials of the American Telegraph and Telephone Company, is considered by this office to be absolutely indecipherable."

Washington, I induced the Chief Signal Officer to resuscitate two equipments. These I employed, believe it or not, in compiling codes, called Division Field Codes, for use in training or in an emergency. I won't undertake to explain how I performed this stunt, for it was a stunt, but it worked very successfully. The codes were duly printed, issued and used until there was no longer any need for codes of this type.

Cipher printing telegraphy was placed upon the shelf and more or less forgotten by Signal Corps communications engineers from 1920 until soon after Pearl Harbor. However, the leading members of the S. I. S. maintained a theoretical cryptanalytic interest in such equipment, and in 1931 there came an opportunity to test such theories as were developed by them when a machine produced by the International Telephone and Telegraph Company evoked the interest of the Department of State as a possible answer to the needs of that Department for rapid and secure cryptocommunications by radio. The Secretary of State requested the Secretary of War to study the machine, which was to be associated with a standard teleprinter, and to study it only from the point of view of security. For this purpose messages enciphered by the Chief of the Communications and Records Division of the Department of State were provided. Here are two pictures of the teleprinter attachment. (Figs 145a, and 145b.) It is a source of satisfaction to be able to tell you that the S.I.S. quickly solved the test messages and therefore reported that the machine was quite insecure; but it is with much regret that I must now tell you who invented and developed the machine. It was a retired officer of the Signal Corps and none other than my old friend Colonel Hitt. I was as embarrassed to tell

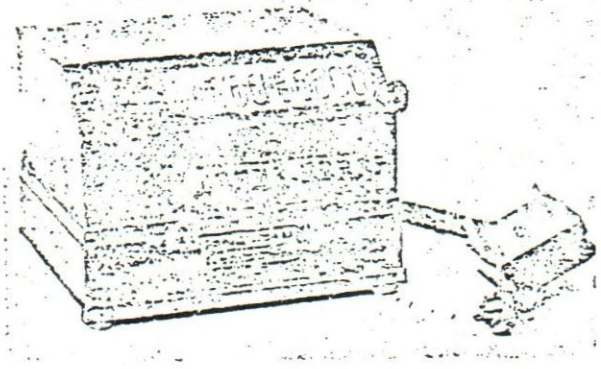

Figure 145a.

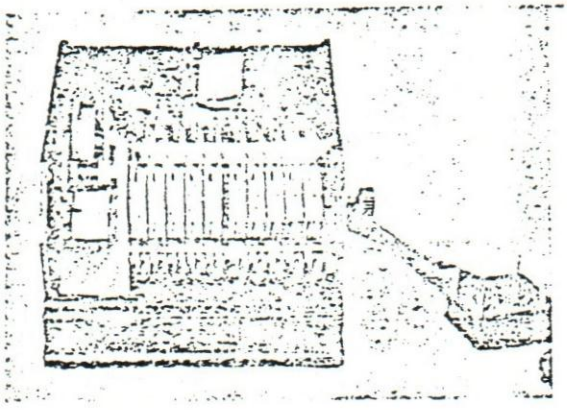

Figure 145b.

him about the results of our test as he was to force himself to listen to what I had to say about the inadequacies of his brain child. As is so often the case, when a competent technician has to neglect his technical studies because of the pressure of administrative duties, he unfortunately finds it very difficult to keep abreast of new developments and progress in a field in which he was at one time an expert. The I. T. & T. Company, having spent a great deal of money on the development of a machine which hardly presented any room at all for improvement because the principles underlying it were so faulty, dropped further work on it. Colonel Hitt, I am glad to say, readily survived the disappointment and was well enough in 1942 to be able to return to active duty during World War II and retired a second time at the end of hostilities. He lives a quiet life now, on a small farm near Front Royal, Virginia.

Beginning about 1938, Mr. Frank B. Rowlett, one of my associates, and I kept urging that there was or would be real need for new and improved machines for protecting teleprinter communications. There was not only a complete lack of interest in such apparatus, but what was perhaps the important factor in the failure to continue work in this field was the lack of funds for research and development for such work.

Our more-or-less sudden entry into World War II, after 7 December 1941, immediately brought a great need for cipher printing telegraphy, especially for radiocommunication, but

there was no apparatus for it whatever—not a single one of those A. T. & T. Company machines of 1918–1920 was in existence. But the S.I.S. did have drawings in readiness, and the development of the machines was given as a priority task to the Teletype Corporation, because that firm had proved that it had the necessary know-how when it produced the SIGABA–ECM's for us. Navy had less need for cipher printing telegraphy than Army because the use of printing telegraphy by radio was then not practicable for ships at sea. However, Navy did have a need for such apparatus for its land communications and joined Army in the procurement thereof. The machines were produced with a remarkable speed by the Teletype Corporation. Most of them were allotted to Army, a few to Navy. The Army called the machine the SIGCUM; the Navy called it CSP–1515. Under heavy use in service, improvements were made both in regard to mechanical and electrical features and in regard to methods of keying, the use of indicators, etc. But I must tell you that before those machines became available in quantity there was only one recourse: we went back to the use of the double-key-tape method using standard teletype apparatus. The cipher was practically the same as it was in 1920, but we had safer methods of key-tape production and indicators for their use. The S.I.S. and the equivalent unit in Navy were not happy because operator's errors left messages open to solution, so that when the new cipher machines were ready they were pressed into service as soon as possible, priority being given to circuits with heavy traffic.

Cryptographic equipments of the foregoing type fall in the category of apparatus for protecting *literal* cryptocommunications because the latter employ letters of the alphabet; but apparatus for protecting *cifax* transmissions, that is, picture or facsimile transmissions, and apparatus for protecting *ciphony* transmissions, that is, telephonic communications, were also developed. But there isn't time to go into details with regard to machines and apparatus for these last two categories of crypto-equipments although the history of their development is rather fascinating and very important. I cannot refrain, however, from adding, that in every case except one, the apparatus was produced by commercial research and development firms with direct guidance from the cryptologists of the Army and the Navy. The one exception is, I believe, in the case of the extremely high security ciphony system and equipment developed and built by the A. T. & T. Company. It was called SIGSALY. There were six terminals, each of which cost over $1,000,000. But NSA cryptologists and engineers have produced smaller and better equipments based upon SIGSALY principles, and such equipments are bound to play extremely important roles in any wars in the future.

So much for the history of the developments and progress in cryptographic apparatus at this point. I shall return to that phase of cryptologic history before the close of this lecture. Right now I shall say a few words about the history of the developments and progress in cryptanalytic apparatus.

Perhaps long before my time cryptanalysts in Europe discovered that the use of sliding strips of paper could sometimes facilitate reaching a solution to a cryptanalytic problem, but so far as I am aware the very first cryptanalytic aid made in the U.S. is the one shown in Fig. 145, which is a picture of what I made at Riverbank and which I called the *Polyalphabet*. It was useful in solving ciphers which today are regarded as being of the very simplest types. When I came to Washington after leaving Riverbank, I wasn't troubled by a plethora of ideas for cryptanalytic aids—I was preoccupied with devising and inventing cryptographic aids and machines. But I did now and then develop and try out certain ideas for cryptanalytic aids, frequency counters, comparison or coincidence machinery, and the like. Why didn't I think of IBM machines? I did, but what good did that do? Did the Signal Office have any such machines—or even one dollar for their rental? You know the answer to that without my spelling it out. There wasn't any use even in suggesting that IBM machines could be of assistance to me—remember, now, that I'm talking about the years from 1921 to 1933, and in the last-named year we were in the depths of a great economic depression. But one day in the summer of 1934 I learned by a devious route (Army and Navy were not then sharing secrets) that the Navy Code and Signal Section had an IBM machine or two, and my chagrin was almost unbearable. Not long afterwards I learned that a certain division of the Office of the Quartermaster General in the Muni-

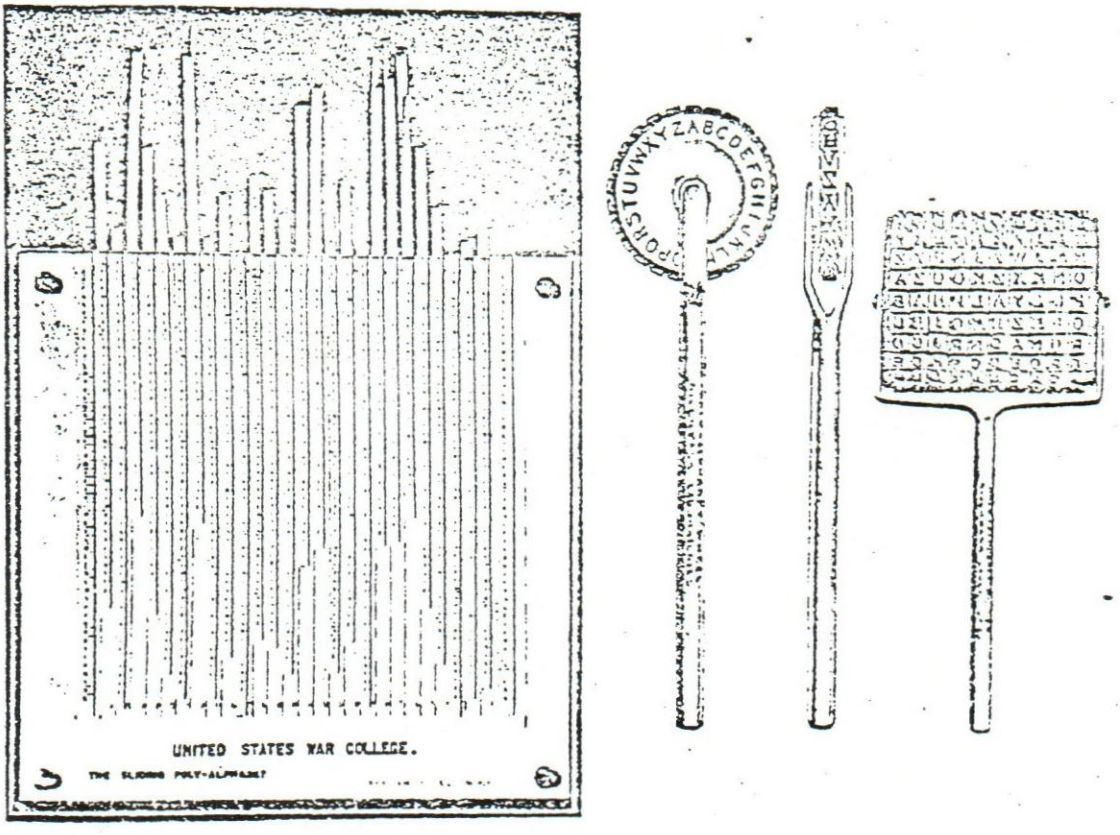

Figure 146.

tions Building had an IBM installation which had been used for accounting purposes in connection with the C.C.C. —the Civilian Conservation Corps, established to provide work and subsistence for young men who could find no jobs in the depression. I also learned that a new officer had just been assigned to head that particular division —and that he just had no use for the new fangled-ideas of his predecessor and wanted to get rid of those nasty IBM machines. But the con-

tract with IBM still had some months to run before the lease expired and either the machines would sit idle or the Government would lose money by terminating the contract before the due date of expiration. This annoyed me, but it also gave me an idea and I wrote the following memorandum:

30 October 1934

Major Akin:

In many years service here I have never once "set my heart on" getting something I felt desirable. But in this case I have set my heart on the matter because of the tremendous load it would lift off all our backs.

The basic idea of using machinery for code compilation is mine and is of several years' standing. The details of the proposed system were developed in collaboration with Mr. Case of the Int. Bus. Machines Corp.

I regard this as one of my most valuable contributions to the promotion of the work for which we are responsible.

Please do your utmost to put this across for me. If you do, we can really begin to do worthwhile *cryptanalytic* work.

Attached to the memo was a brief explanation amounting to what I've told you about that IBM installation in the Office of the Quartermaster General. Note that I placed the emphasis upon the burden that would be lifted from cryptographic work by using the IBM machinery, thus leaving more time for cryptanalytic work. This was because the responsibilities of the S.I.S. for cryptanalytic operations were at that time restricted purely to theoretical studies. Studies on cryptanalytic work on foreign cryptosystems had been a responsibility of G-2 of the General Staff until 1929, when that responsibility had been transferred to the Chief Signal Officer and the Signal Corps in the year named. But the Signal Officer had very little money to use for that purpose, and, besides that, the Army Regulation applicable thereto specifically restricted cryptanalytic operations on foreign communications to wartime. And more to the point was the fact that there was no material to work on even if funds were available, because the Army had at that time no intercept stations whatever, anywhere in or outside the U.S. But that's another story, and I'll proceed to the next point, which is that my memo to Major Akin produced results. Just a half month after I wrote and put it in his "In" basket I got the machines moved from the Office of the Quartermaster General to my own warren in the Office of the Chief Signal Officer! That memo must have been potent magic.

Once having demonstrated their utility to the Chief Signal Officer, the almost prematurely terminated contract with IBM was renewed—and soon expanded. I don't know how we could have managed without such machines during World War II.

We built or had built for us by IBM and other concerns adaptors to work with standard IBM machines; we constructed or had constructed for us by commercial firms highly specialized cryptanalytic apparatus, machines and complex assemblies of components. Under wartime pressures fantastic things were accomplished and many were the thrills of gratifying achievement when things that just couldn't be done were done—and were of high importance in military, naval and air operations against the enemy.

Even were time available I couldn't show you pictures of some of the high-class gadgets we used, neither is it permissible to say more than I have already said about them, even though it is no longer a deep secret that electronic computers are highly useful in cryptologic work.

To the layman the exploits of professional cryptanalysts, when those exploits come to light as, for example, in the various investigations of the attack on Pearl Harbor, are much more fascinating than those of cryptographers, whose achievements in their field appear in comparsion to be dull or tedious to the layman. But long consideration of the military importance of COMSEC as against COMINT leads me to return to something I mentioned at the very beginning of this lecture, when I made a statement to the effect that cryptography and cryptanalysis represent the obverse and reverse faces of the same single coin. In closing this lecture I will expand that statement a bit, and in so doing perhaps formulate a dictum which we may call the law governing the minting and usage of the cryptologic combat coin. It would run something like this:

When an officer is selected to command a fighting unit, an efficient appointing authority gives him and entrusts into his care a top secret, magic talisman of great potency, a coin which is called his cryptologic combat coin, and which, as is usual in the case of all but trick coins, has two faces, a COMINT face and a COMSEC face. When given to him that coin should be in mint condition, it should be bright and shiny on both faces, and he should strive his utmost to keep them both that way. If, to begin with, he is given a coin that is tarnished a bit on both faces, he is really starting out with a great handicap, no matter how good he and his forces are in respect to size, equipment, training and ability. If he keeps both faces bright and shiny, he stands a good chance of winning a battle even if his forces are inferior in size, etc., compared with those of the enemy. But if he lets either face of his coin become dull from indifference, carelessness, or ignorance, he will almost surely lose the battle, even if his forces are superior in size, etc., compared with those of the enemy.

As a remarkable example of the validity of the foregoing dictum, an example that comes directly from the two Japanese Navy officers who wrote *Midway: The Battle that Doomed Japan* (see footnote 12 above), let me quote the initial paragraphs of the Preface to their book (p. xiii):

> "For Japan, the Battle of Midway was indeed a tragic defeat. The Japanese Combined Fleet, placing its faith in "quality rather than quantity," had long trained and prepared to defeat a numerically superior enemy. Yet at Midway a stronger Japanese force went down to defeat before a weaker enemy.
>
> Not only were our participating surface forces far superior in number to those of the enemy, but the initiative was in our hands. Nor were we inferior, qualitatively, in the crucial element of air strength, which played the major role throughout the Pacific War. In spite of this we suffered a decisive defeat such as the modern Japanese Navy had never before experienced or even dreamed possible."

Earlier in this lecture (see p. 134), I quoted two other paragraphs from this same book, in which the Japanese authors make perfectly clear the reasons for the loss of the Battle of Midway, reasons which have also been stated by other writers. The cryptologic combat coin our Navy entrusted to Admiral Nimitz was highly polished and bright on both sides; the one the Japanese Navy entrusted to Admiral Yamamoto was dull on both sides to begin with. Admiral Yamamoto not only didn't even know how tarnished it was; he lost his life because of his ignorance a couple of years later. Neither he nor his superiors had the experience and knowledge that were necessary to polish up that coin. It took almost ten years for the truth of that dictum I formulated for you a moment or two ago to become clear to the Japanese Navy. Had they taken quick and full advantage of the unfortunate leakage of the vital COMINT facts soon after the Battle of Midway, they could and perhaps would have come to the proper conclusions long before they did. Who knows what the results might have been, and the effect thereof, on the outcome of the war in the Pacific?

Hardly anything of importance in the cryptologic battles of World War II escaped the attention of Winston Churchill, who even 'way back in 1915, when he was First Sea Lord of the British Navy in World War I, had taken a great interest in cryptology. He made the following final comment on the Battle of Midway, a comment that is impressive in its guarded revelations and in its restraint:[23]

> "One other lesson stands out. The American intelligence system succeeded in penetrating the enemy's most closely guarded secrets well in advance of events. Thus Admiral Nimitz, albeit the weaker, was twice able to concentrate all the forces he had in sufficient strength at the right time and place. When the hour struck this proved decisive. The importance of secrecy and the consequences of leakage of information are here proclaimed."

It will probably seem to many of my listeners and readers that I have paid more tributes to the achievements of our Navy cryptanalysts in World War II than to those of their Army and Air Force opposite numbers. If I have done so, I can only say in extenuation that three factors are here involved. First, as regards my apparent overlooking of the contributions of the USAF,

[23] *The Hinge of Fate.* Vol. IV. Boston: Houghton Mifflin Co., 1950, p. 252-3.

I need but remind you that it wasn't until after the war was all over that the Army Air Corps became autonomous; before then the technical achievements of cryptanalysts of that Corps were merged with those of the Army. Second, as a member of the Army's Signal Intelligence Service, and then the Army Security Agency during World War II, it is fitting that somebody other than I blow the trumpets in celebration of our Army's cryptanalytic achievements. All I will say is that they were as important as those of our Navy, but for various reasons they have not received much publicity, which is just as well from the point of view of National Security. As a matter of fact, the publicity regarding our Navy's cryptologic successes comes very largely from former enemy officers and from the various official investigations into the attack on Pearl Harbor, and not from any U.S. Navy personnel. Third, there has been very little leakage with regard to Army's cryptanalytic successes except such as can also be traced back to those Pearl Harbor investigations. General Eisenhower's *Crusade in Europe* has not one word to say on the subjects of signal intelligence, cryptanalysis, codes, ciphers, or signal security, etc., although he does make a few rather caustic remarks about the *failures* and *errors* of his own intelligence staff. General Bradley's book is equally reticent on these subjects but I cannot refrain from quoting one rather amusing episode having to do with COMSEC:

> To identify hills, road junctions, and towns without our giving our plans away in the event of an enemy tap on the wire, I had key features numbered on my war map and gave copies of those numbers to the division commanders. It was a makeshift private code, lax enough to cause Dickson [Bradley's G–2] to worry over the security of our plans.
>
> One morning when I called Major General Terry Allen, he referred to an obscure crossroad by its number in this private code.
>
> "Just a minute, Terry," I said. "I can't find that number on my map."
>
> "Well, listen carefully, Brad," he said. "The enemy may be listening in. I'll say the name of the place as fast as I can."
>
> Dickson overheard this conversation and threw up his hands. "Security wouldn't be much of a problem," he said, "if only there were fewer generals in the army."

General Hap Arnold's book I've mentioned before and have taken one extract from it. There are several others I might have used, but they are not too significant in revelations. One volume of the history of the U.S. Army in World War II, entitled "The Signal Corps" contains a few references to the achievements of the Signal Intelligence Service, but these, too, are not very illuminating. In only one book by a former U.S. Army Officer, Col. Robert S. Allen, entitled *Lucky Forward: The History of Patton's Third Army*,[24] do I find a specific reference to the help the SIS gave Patton. In telling about Patton's signal officer, Colonel Hammond, Allen writes:

> "One of his ace units was the SIS. A radio-interception agency, commanded by Major Charles Flint, a young, trigger-smart expert, it worked closely with G–2 on a dual mission: maintaining a vigilant security check on friendly communications and intercepting enemy messages. The unit performed outstandingly in both fields.
>
> Its reports plugged up an unwitting leak from a Mechanized Cavalry source, capable of revealing important troop-movement information to the enemy. And at a critical period in the Battle of Bastogne, the unit broke a German coded message that enabled heavy losses to be inflicted upon the redoubtable 5 Para Division. The SIS was particularly fruitful in breakthroughs and fluid situations when the enemy was on the run and had to use radio."

The foregoing extract is, of course, far from spectacular. Indeed, I imagine that it will hardly bring forth more than a polite yawn from many members of an audience that has already learned about the sensational revelations made during the various Pearl Harbor investigations and about those famous letters that General Marshall wrote to Governor Dewey. But there remains this much more to be said: the achievements of our Army's cryptologic units both in Washington and in the field, as well as certain still undisclosed top secret suc-

[24] New York: The Vanguard Press, Inc., 1957, p. 56. The author makes some quite caustic comments about the failure of the intelligence staffs to make use of the intelligence they were furnished. They are worth reading.

cesses of our Navy's units ashore and afloat, are locked away in archives where they will probably remain for a long, long time. More than this I am not at liberty to tell you in this lecture.

With this statement I bring this series to a rather undramatic but I hope meaningful close. I will wind it up by paraphrasing the last sentence of the Introduction to that important book *The Battle of Midway* from which I have quoted at some length. The Introduction was written by Admiral Nobutake Kondo, the senior living commander of the former Imperial Navy, who participated in that battle: I close this series with the hope that my lectures will serve as material for criticism and reflection.

APPENDIX I

From *Time* Magazine, 17 December 1945

MAGIC WAS THE WORD FOR IT

U.S. citizens discovered last week that perhaps their most potent secret weapon of World War II was not radar, not the VT fuse, not the atom bomb—but a harmless little machine which cryptographers painstakingly constructed in a hidden room at Fort Washington.

With this machine, built after years of trial and error, of inference and deduction, cryptographers had duplicated the decoding devices used in Tokyo. Testimony before the Pearl Harbor Committee had already shown that the machine—known in Army code as "Magic"—was in use long before Dec. 7, 1941, had given ample warning of the Jap's sneak attack—if only U. S. brass hats had been smart enough to realize it (Time Dec. 10). Now General Marshall continued the story of "Magic's" magic. It had:

Enabled a relatively small U.S. force to intercept a Jap invasion fleet, win a decisive victory in the Battle of the Coral Sea, thus saving Australia and New Zealand.

Given the U.S. full advance information on the size of the Jap forces advancing on Midway, enabled the Navy to concentrate ships which otherwise might have been 3,000 miles away, thus set up an ambush which proved to be the turning-point victory of the Pacific war.

Directed U.S. submarines unerringly to the sea lanes where Japanese convoys would be passing.

By decoding messages from Japan's Ambassador Oshima in Berlin, often reporting interviews with Hitler, given our forces invaluable information on German war plans.

UNEASY SECRET

So priceless a possession was Magic that the U.S. high command lived in constant fear that the Japs would discover the secret, change their code machinery, force U.S. cryptographers to start all over again.

General Marshall had a long series of bad moments after U.S. flyers, showing a suspicious amount of foresight, shot down Admiral Yamamoto's plane at Bougainville in 1943. Gossip rustled through the Pacific and into Washington cocktail parties; General Marshall got to the point of asking the FBI to find an officer "who could be made an example of." (The FBI, fearful of looking like a Gestapo, refused.)

Once a decoder was caught in Boston trying to sell the secret. Once, well-meaning agents of the Office of Strategic Services ransacked the Japanese Embassy in Lisbon, whereupon the Japs adopted a new code for military attachés. This code remained unbroken more than a year later.[1] The worst scare of all came during the 1944 presidential campaign, when George Marshall heard that Thomas E. Dewey knew the secret and might refer to it in speeches (*see below*).

Yet for all these fears, the Japs never discovered that the U.S. was decoding their messages. Even after the surrender the Army still used Magic as a guide to occupation moves: though it had once been planned to send a whole army into Korea, Magic showed that a single regiment would be enough.

SECRET KEPT

The letter, on stationery of the Chief of Staff's Office, bore a bold heading: TOP SECRET. FOR MR. DEWEY'S EYES ONLY. Candidate Thomas E. Dewey, his curiosity piqued, read rapidly through the first two paragraphs:

I am writing you without the knowledge of any other person except Admiral King (who concurs) because we are approaching a grave dilemma in the political reactions of Congress regarding Pearl Harbor.

---

[1] While I have no recollection of the Boston business, I shall never forget the Lisbon incident.—W.F.F.

What I have to tell you below is of such a highly secret nature that I feel compelled to ask you ...her to accept it on the basis of your not communicating its contents to any other person and returning this letter or not reading any further and returning the letter to the bearer.

Tom Dewey looked up from the typewritten page. As he did, the word *cryptograph*, a few paragraphs below, flashed into his vision like a red traffic light. He made his decision quickly, folded the letter, handed it back. Colonel Carter W. Clarke (in mufti), who had flown from Washington to Tulsa to catch up with Tom Dewey's campaign, went back, his mission uncompleted.

YOU HAVE MY WORD

It was September 1944. The campaign train rolled up through the Midwest, returned to Albany. A few days later, Tom Dewey received another visit from Colonel Clarke.[1]

The Colonel, again in civilian clothes, handed over another letter from General Marshall. The General had changed his mind somewhat:

I am quite willing to have you read what comes hereafter with the understanding that you are bound not to communicate to any other person any portions on which you do not now have or later receive factual knowledge from some other source than myself. . . . You have my word that neither the Secretary of War nor the President has any intimation whatsoever that such a letter has been addressed to you. . . .

THE LOCKED FILE

This time Tom Dewey read on. As he turned the pages, he became the first man outside the high command to know the full story of "Magic" and what it was accomplishing in the war against the Japs (*see above*). The letter closed with a plea:

I am presenting this matter to you, for your secret information, in the hope that you will see ...ur way clear to avoid the tragic results with which we are now threatened in the present political campaign.

Tom Dewey locked the letter in his files, went back to his electioneering. Though he had known before that the U.S. had cracked the Jap code, had suspected that this information cast grave doubts on Franklin Roosevelt's role before Pearl Harbor, he held his tongue. The War Department's most valuable secret was kept out of the campaign.

MEETING AT A FUNERAL

Recounting this story at the Pearl Harbor hearing last week, General Marshall recalled that he and Tom Dewey had never discussed the matter in person until they met at Franklin Roosevelt's funeral last April: "I asked Mr. Dewey to come with me to the War Department and I showed him current Magic showing Japanese movements. His attitude was friendly and gracious."

Had Marshall ever told Franklin Roosevelt of the letters to Dewey? Said Marshall: "The President died without knowing of it."

SECRET LOST

The Pearl Harbor Committee blithely tossed away one still-secret U.S. weapon. George Marshall's letters to Governor Dewey (*see above*) mentioned that the U.S., with the help of the British, had decoded German as well as Japanese messages. George Marshall begged the Committee to cut out these references. The Committee refused.

Publication of the letters thus gave the Germans their first knowledge that their code had been broken. It was also a breach of diplomatic confidence with the British, who had let the U.S. in on the secret on the understanding that it would be kept.

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[1] "A few days later . . ." But note that the first letter is dated 25 September 1944, the second, 27 September. It is possible that Colonel Clarke was unable to deliver the letter, but my recollection is that he did deliver it the very next day.—W.F.F.

ANATOMY OF CONFUSION

Up to the witness stand stepped Lieut. General Leonard T. Gerow, chief of the Army's War Plans Division in 1941, to accept full blame for one of Pearl Harbor's most egregious errors. On Nov. 27, a sharp warning of impending hostilities had gone out from General Marshall to Lieut. General Walter C. Short in Hawaii. On Nov. 28, General Short replied that he had ordered an alert against sabotage—which was like saying he had a butterfly net ready for a tiger. Yet his reply was never challenged by Washington. Why?

Explained General Gerow: he thought the Short message was an answer to other communications. Said he: "If there is any responsibility in the War Department for failure . . . I accept that responsibility."

Then up stepped General Marshall himself to take part of the blame. He didn't recall seeing the Short message; he should have. "That was my opportunity to intervene and I didn't take it," he confessed. "Just why, I do not know."

FOURTEEN POINTS

The week's testimony also shed light on the warning that came too late—the message Walter Short received on Dec. 7 at 2:58 p.m. Hawaiian time informing him that the Japs were on the way.

On the night of Dec. 6, Major General Sherman Miles, Chief of Intelligence, received from "Magic" decoders the first thirteen points of the strongly worded, final Jap diplomatic note being sent from Tokyo to its envoys in Washington. Next morning, some time between 7 and 8 o'clock, an assistant telephoned that he had "important" information. General Miles reached his office at 9 o'clock.

General Marshall had risen early, breakfasted at 8, looked over the Sunday papers, gone out for a horseback ride. (He usually rode for 50 minutes.) He was in the shower when an urgent message arrived by telephone from General Miles' assistant. He finished his bath, dressed quickly and went straight to the War Department. The time: 11:25 a.m.

WHO'S CONFUSED?

A hastily gathered staff meeting decided that the Jap note meant war, that a warning should go immediately to Hawaii, the Philippines, the West Coast, the Canal. General Marshall called Admiral Harold R. ("Betty") Stark, then Chief of Naval Operations. "Betty" Stark thought by some obscure reasoning that further warnings would "only confuse" field commanders.

General Marshall wrote out a warning anyway, called Admiral Stark again to read it. Stark decided on second thought that the warning might as well go to Navy commanders as well. General Marshall sent it on to the Signal Corps which promised, according to General Miles, that it would be delivered in 20 minutes. It was then 11:50 a.m.; the attack was one hour and ten minutes away.

Instead of 20 minutes, the Signal Corps took eight hours and 28 minutes to get the message to Short (by commercial cable instead of Army radio). Nobody had bothered to check up on the Signal Corps; the General Staff took for granted that the message was going full speed ahead.

Why hadn't General Marshall used the telephone? His explanation: he knew that many phone calls—including transatlantic talks between Franklin Roosevelt and Winston Churchill—had been tapped; he feared that the Japs would intercept his call and label it an "overt act." Anyway, he said, even if he had phoned he would first have called the Philippines, where he thought the real danger lay.

Said George Marshall: "We thought Hawaii was the most improbable [target] of all. . . . I was inclined to feel the hazards were too great and they would not risk it."

APPENDIX II

The Letters from General Marshall to Governor Dewey, 25 and 27 September 1944

The Marshall-Dewey correspondence is so important in cryptologic history that I feel that the whole of it should be included even in this brief history. When the letter was written, it was, of course, TOP SECRET and it was only under great pressure from certain members of the Joint Congressional Committee that General Marshall revealed its contents.[1] Thus, it came into the public domain not only on the very day that General Marshall was forced to place it in evidence—its publication caused a great sensation in the newspapers—but also when the 40 volumes of the *Hearings* of that Committee were published and put on sale by the Superintendent of Documents of the Government Printing Office. The disclosure of the contents of the Marshall-Dewey correspondence was indeed such a sensation that *Life* magazine printed the whole of it in its issue of 17 December 1945, with the following introduction:

MARSHALL-DEWEY LETTERS

General Told Candidate We Had Broken Jap Code

During the 1944 election campaign General George C. Marshall wrote two letters to Republican Candidate Thomas E. Dewey, telling him that Army cryptographers had broken the Japanese "ultra" code. This fact was first revealed in a story by *Life* Editor, John Chamberlain, which appeared in *Life*, Sept. 24. Marshall's purpose, Chamberlain wrote, was to forestall Dewey's revelation of that fact in a possible attack on the Roosevelt administration's Japanese policy before Pearl Harbor. The actual text of the letters remained secret until last week, when General Marshall appeared before the Congressional Committee investigating Pearl Harbor and made the letters public. They appear below.

When he had finished reading the first two paragraphs of the first letter, Governor Dewey stopped because, as the Chamberlain article reported, "the letter might possibly contain material which had already come from other sources, and that anyway, a candidate for President was in no position to make blind promises." General Marshall sent the letter back again with an introduction which relieved the governor of binding conditions. This time Dewey read the letter and after much thought and discussion decided not to make use during the campaign of any information he previously had.

First Letter

TOP SECRET

(FOR MR. DEWEY'S EYES ONLY)

25 September 1944

My Dear Governor:

I am writing you without the knowledge of any other person except Admiral King (who concurs) because we are approaching a grave dilemma in the political reactions of Congress regarding Pearl Harbor.

What I have to tell you below is of such a highly secret nature that I feel compelled to ask you either to accept it on the basis of your not communicating its contents to any other person and returning the letter or not reading any further and returning the letter to the bearer.

I should have preferred to talk to you in person but I could not devise a method that would not be subject to press and radio reactions as to why the Chief of Staff of the Army would be seeking an interview with you at this particular moment. Therefore, I have turned to the method of this letter, to be delivered by hand to you by Colonel Carter Clarke, who incidentally has charge of the most secret documents of the War and Navy Departments.

In brief, the military dilemma resulting from Congressional political battles of the political campaign is this:

[1] So far as I am aware it has neither been ascertained nor disclosed, if known, who gave Governor Dewey the information. But it is a fact that as a patriotic citizen, he acceded to General Marshall's request—he made no use whatever of the vital secret information during the campaign or after it. *Time's* account specifically states that Dewey "held his tongue." The War Department's most valuable secret was kept out of the campaign." I know this to be true.—W.F.F.

The most vital evidence in the Pearl Harbor matter consists of our intercepts of the Japanese diplomatic communications. Over a period of years our cryptograph people analyzed the character of the machine the Japanese were using for encoding their diplomatic messages. Based on this, a corresponding machine was built by us which deciphers their messages.

Therefore, we possessed a wealth of information regarding their moves in the Pacific, which in turn was furnished the State Department—rather than, as is popularly supposed, the State Department providing us with information—but which unfortunately made no reference whatever to intentions toward Hawaii until the last message before Dec. 7, which did not reach our hands until the following day, Dec. 8.

Now the point to the present dilemma is that we have gone ahead with this business of deciphering their codes until we possess other codes, German as well as Japanese, but our main basis of information regarding Hitler's intentions in Europe is obtained from Baron Oshima's message from Berlin reporting his interviews with Hitler and other officials to the Japanese Government. These are still in the codes involved in the Pearl Harbor events.

To explain further the critical nature of this setup which would be wiped out almost in an instant if the least suspicion were aroused regarding it, the Battle of the Coral Sea was based on deciphered messages and therefore our few ships were in the right place at the right time. Further, we were able to concentrate our limited forces to meet their advances on Midway when otherwise we almost certainly would have been some 3,000 miles out of place.[4]

We had full information of the strength of their forces in that advance and also of the smaller force directed against the Aleutians which finally landed troops on Attu and Kiska.

Operations in the Pacific are largely guided by the information we obtain of Japanese deployments. We know their strength in various garrisons, the rations and other stores continuing available to them and what is of vast importance, we check their fleet movements and the movements of their convoys.

The heavy losses reported from time to time which they sustain by reason of our submarine action largely results from the fact that we know the sailing dates and the routes of their convoys and can notify our submarines to lie in wait at the proper point.

The current raids by Admiral Halsey's carrier forces on Japanese shipping in Manila Bay and elsewhere were largely based in timing on the known movements on Japanese convoys, two of which were caught, as anticipated, in his destructive attacks.

You will understand from the foregoing the utter tragic consequences if the present political debates regarding Pearl Harbor disclose to the enemy, German or Jap, any suspicion of the vital sources of information we now possess.

The Robert's report on Pearl Harbor had to have withdrawn from it all reference to this highly secret matter, therefore in portions it necessarily appeared incomplete. The same reason which dictated that course is even more important today because our sources have been greatly elaborated.

As a further example of the delicacy of the situation, some of Donovan's people (the OSS), without telling us, instituted a secret search of the Japanese Embassy offices in Portugal. As a result the entire military attache Japanese code all over the world was changed, and though this occurred over a year ago, we have not yet been able to break the new code and have thus lost this invaluable information source, particularly regarding the European situation.

A recent speech in Congress by Representative Harness would clearly suggest to the Japanese that we have been reading their codes though Mr. Harness and the American public would probably not draw any such conclusion.

The conduct of General Eisenhower's campaign and of all operations in the Pacific are closely related in conception and timing to the information we secretly obtain through these intercepted codes. They contribute greatly to the victory and tremendously to the saving of American lives, both in the conduct of current operations and in looking toward the early termination of the war.

I am presenting this matter to you, for your secret information, in the hope that you will see your way clear to avoid the tragic results with which we are now threatened in the present political campaign. I might add that the recent action of Congress in requiring Army and Navy investigations for action before certain dates has compelled me to bring back the corps commander, General Gerow, whose troops are fighting at Trier, to testify here while the Germans are counterattacking his forces there. This, however, is a very minor matter compared to the loss of our code information.[5]

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[4] In regard to this and the succeeding four paragraphs, see my comment below (p. 122).

[5] The last two sentences in this paragraph were omitted from the Second Letter. See footnote[4].

Please return this letter by bearer. I will hold it in my secret file subject to your reference should you so desire.

Faithfully yours,
G. C. Marshall

Second Letter

TOP SECRET

(FOR MR. DEWEY'S EYES ONLY)

27 September 1944

My Dear Governor:

Colonel Clarke, my messenger to you of yesterday, Sept. 26, has reported the result of his delivery of my letter dated Sept. 25. As I understand him you (A) were unwilling to commit yourself to any agreement regarding "not communicating its contents to any other person" in view of the fact that you felt you already knew certain of the things probably already referred to in the letter, as suggested to you by seeing the word "cryptograph," and (B) you could not feel that such a letter as this to a Presidential candidate could have been addressed to you by an officer in my position without the knowledge of the President.

As to (A) above I am quite willing to have you read what comes hereafter with the understanding that you are bound not to communicate to any other person any portions on which you do not now have or later receive factual knowledge from some other source than myself. As to (B) above you have my word that neither the Secretary of War nor the President has any intimation whatsoever that such a letter has been addressed to you or that the preparation or sending of such a communication was being considered.

I assure you that the only persons who saw or know of the existence of either this letter or my letter to you dated Sept. 25 are Admiral King, seven key officers responsible for security of military communications, and my secretary who typed these letters.

I am trying my best to make plain to you that this letter is being addressed to you solely on my initiative, Admiral King having been consulted only after the letter was drafted, and I am persisting in the matter because the military hazards involved are so serious that I feel some action is necessary to protect the interests of our armed forces.

(*The second letter then repeated substantially the text of the first letter except for the first two paragraphs*).

Life failed to note that the last two sentences in the penultimate paragraph of the "First Letter" were omitted from that paragraph in the "Second Letter," but there is no explanation for the omission.[4] Perhaps it was simply for the sake of brevity, but this seems improbable.

In my first lecture I called attention to the fact that the account given in the *Time* article gives credit to Army cryptanalysts for providing the secret communication intelligence "which enabled our Navy to win such spectacular battles as those of the Coral Sea and Midway, and to waylay Japanese convoys," whereas the credit for the communication intelligence which enabled our Navy to win these battles was produced by Navy cryptanalysts. One cannot blame the editors of *Time* for making such a bad error because the source of the error can be traced directly to General Marshall's letter itself. Several years ago I asked my friend Colonel Clarke, who, you will recall, carried General Marshall's letter to Governor Dewey, how such an error had crept into General Marshall's letter and was told that the letter which had been prepared for General Marshall's signature did not meet with the General's wholehearted approval and that the General himself had modified it. Perhaps that is how the error to which I have referred crept into it. One could hardly expect General Marshall to be entirely familiar with the technical cryptanalytic details involved in what he wanted to tell Governor Dewey, nor should one criticize him for not being able, in his very busy days and under very heavy pressure of events, to bear in mind or even to know about the differences between the enemy systems worked upon by the respective and separate Army and Navy cryptanalytic organizations. It is of course possible, indeed it may be, that in the cases of certain important naval operations valuable COMINT came from messages read by Army cryptanalysts, and this may

[4] The sentence beginning "I might add . . ." and the one beginning "This, however is . . ." were omitted.

be what confused General Marshall in implying that all the credit belonged to them because of their solution of the Japanese highest-level diplomatic cryptosystems, the one that used the so called "Purple Code," which wasn't a "code" but a cipher machine.

Since the period during which the disclosures of the Joint Congressional Investigation were made, disclosures which were disastrous so far as the important accomplishments of the two services, before and after the Pearl Harbor attack, in the field of communications intelligence, much has been written and is now in the public domain regarding those accomplishments, but fortunately no technical details of significance have been disclosed.

BIOGRAPHICAL SKETCH

WILLIAM F. FRIEDMAN—B.S. (genetics), Cornell University, 1914; Research Fellow, New York State Experiment Station, Geneva, N.Y., 1914; Graduate Student and Instructor in Genetics, Cornell University, 1914–1915; Director, Dept. of Genetics, Riverbank Laboratories, Geneva, Ill., 1915–1916; Director, Depts. of Ciphers and Genetics, Riverbank Laboratories, 1916–1918; 1st Lt., N.A., serving in Code and Cipher Solving Section, G2, GHQ AEF, Chaumont, France, 1918–1919 (retired as Lt. Col., USAR, 1951); Director, Dept. of Ciphers, Riverbank Laboratories, 1919–1920; Cryptographer, OCSigO, Washington, D.C., 1921; Cryptanalyst, War Department, 1922–1947; Director, Communications Research, Army Security Agency, 1947–1949; Cryptologic Consultant, Army Security Agency, 1949; Research Consultant, Armed Forces Security Agency, 1949–1951; Research Consultant, National Security Agency, 1951–1954; Special Assistant to the Director, NSA, 1954–1955 (retirement); Member, NSA Scientific Advisory Board, 1954–; Special Consultant, National Security Agency, 1955–.

For his many contributions to the security of his country, he has received the War Department Medal for Exceptional Civilian Service (1944), the Presidential Medal for Merit (1946), the Presidential National Security Medal (1955), and a special congressional award of $100,000 for inventions and patents in the field of cryptology (1956). For their contributions to literature, he and Mrs. Friedman received the Fifth Annual Shakespeare Award in 1958 from the American Shakespeare Festival Theater and Academy for their book "The Shakespearean Ciphers Examined."

Mr. Friedman is a member of Sigma Xi, the Cosmos Club, the U.S. Naval Institute, and the Shakespeare Association of America. He is listed in *Who's Who in America*, and in *American Men of Science*.

Author of many classified books and brochures, technical treatises and articles on cryptologic subjects; articles in the *Signal Corps Bulletin* (1925–1940); Riverbank Publications on Cryptology (1918–1922), the more important of which are "Several Machine Ciphers and their Solution," "The Index of Coincidence and Its Applications to Cryptography," and "Applications of the Science of Statistics to Cryptography." Technical papers and reports published by the Office of the Chief Signal Officer and by the Signal Intelligence Service (1935–1945), among which may be mentioned "The Principles of Indirect Symmetry of Position in Secondary Alphabets and their Application in the Solution of Polyalphabetic Substitution Ciphers," "American Army Field Codes in the American Expeditionary Forces in the First World War," "Field Codes used by the German Army during the World War," and "Analysis of a Mechanical-Electrical Cryptograph." Encyclopaedia Britannica article on "Codes and Ciphers (Cryptology)," 1927 (revised 1954). "Jacques Casanova, Cryptologist," in *Casanova Gleanings*, Nice, France, 1961. Co-author with his wife, Elizebeth Smith Friedman, of the "Shakespearean Ciphers Examined," 1957; "Acrostics, Anagrams and Chaucer," *Philological Quarterly*, 1959; "The Cryptologist Looks at Shakespeare" (Folger Shakespeare Literary Prize), 1955.

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