MEMO ROUTING SLIP	*NEVER USE FOR APPROVALS, DISAPPROVALS, CONCURRENCES, OR SIMILAR ACTIONS*		
1 NAME OR TITLE: Dr Kullback Jr	INITIALS		CIRCULATE
ORGANIZATION AND LOCATION: 30	DATE		COORDINATION
2 Mr Friedman	WFF		FILE
S/ASST	5 Oct 54	✓	INFORMATION
3 Dr. Kullback		✓	NECESSARY ACTION
R/D			NOTE AND RETURN
4			SEE ME
			SIGNATURE

Suspense Nov [illegible]

REMARKS

This has been turned over to 31 + 35 for study. This stems from the last NSASAB meeting.
Kull.

Pls let me know outcome of study by 31 + 35. WFF.

FROM NAME OR TITLE:	DATE [illegible]
ORGANIZATION AND LOCATION: S	TELEPHONE

August 26, 1954

CODING AND DECODING MACHINE

by A. M. Skellett

It is well known in the Art of Crystography to use a machine for coding and decoding a message, the principle of which is to scramble and unscramble the letters of the alphabet in a predetermined pattern which varies with time. The present invention is electronic and provides such a machine having no moving parts to the end that it may operate at extreme speeds. This extreme speed of operation is especially useful in deciphering a coded message since it provides for the trial of many combinations or scrambling patterns in a relatively short time.

Figure 1 shows an embodiment of the present invention in schematic form. Keys at the left are provided for the letters of the alphabet similar to teletypewriter keys. The original message is fed into the machine here as one might type a message on a teletypewriter. These keys are each connected to an individual radio frequency oscillator which is turned on when its key is depressed. Thus pressing key "A" will cause the "A" oscillator to send out radio waves. Each oscillator operates at a different frequency.

On the right hand side of the figure there is a corresponding number of receivers each turned to a different frequency. Each receiver is connected so as to operate a printing mechanism for a letter of the alphabet. This printing mechanism may be similar to that of the receiving machine of a teletypewriter. For simplicity, no attempt has been made to show this whole mechanism but the solenoid arrangement shown at the output of each receiver represents the actuating mechanism for such a machine. There is one receiver tuned to each of the oscillator frequencies so that waves from one oscillator can be received on only one receiver. Now the tuning of the receivers is set according to the scrambling pattern.

In operation, when Key A is depressed, radio waves of frequency "A" are sent out. Only the second or "B" receiver is tuned to receive the A waves. Thus, the second receiver is actuated and the letter B is printed. Likewise, depression of the H Key, for example, results in the printing of letter F, etc.

Thus, it is seen that a message typed out on the input keys is printed in coded form with the letters scrambled in accordance with the pattern by which the receivers are tuned. Also, it is obvious that if the scrambling pattern is reversed, i.e., if the receivers are tuned to the reversed scrambling pattern, the coded message when typed on the input keys will be deciphered and the original message will be printed.

A message coded as above is fairly easy to decipher by well known methods. However, if the scrambling pattern is changed after each letter, it becomes extremely difficult to decipher the message. It remains to be shown how the pattern is varied with time.

We consider the receivers. They operate on the superheterodyne principle. The incoming frequency f_1 is modulated by a beat frequency f_b supplied by the "beat frequency oscillator". This modulation gives a difference or intermediate frequency (i.f.) which goes through the i.f filter. The tuning of the receiver is provided by the tuning of the i.f. filter. By varying the beat frequency, the receiver is made receptive to correspondingly varying incoming frequencies.

Let us choose some values for the frequencies to better understand the operation. We will assume a beat frequency of one megacycle. We also assume that the oscillator frequencies range from 1.5 mc. to 1.760 mc. This provides a 10 kilocycle separation between adjacent letter oscillators or a total spread of 10 X 26 or 260 kilocycles.

Now, for example, if the B frequency f_b is 1.51 megacycles, then the i.f. of the C receiver (which is tuned to it) is tuned to 510 KC (1.51 - 1.0 mc.) and striking the B Key will print the letter C. The signal from the A oscillator will also be present in the input of the C receiver but will give rise to an i.f. of 500 KC which cannot get through the i.f. filter (band width less than 10 KC). Nor can the signal from the C oscillator get through since this would give an i.f. of 520 KC.

With all the filters tuned to the proper frequencies according to the pattern the one beat frequency maintains all of the i.f. frequencies in proper relation for passing through the filters. Now, suppose we vary the beat frequency by 10 KC. This will shift the reception of each receiver by 10 KC. and thus change the key or scrambling pattern.

Using the example given above, consider that the beat frequency is changed to 0.99 mc. Then $f_b - f_b$ equals 520 KC. instead of 510 KC. and the D receiver will now respond to the B oscillator to print the letter D. This is a shift of one letter in this case but the next shift in beat frequency by 10 KC., i.e. to 0.980 mc., will match the output of the B oscillator to the tuning of the A receiver (i.f = 530 KC.) and the letter A will be written when B key is pressed.

These examples are for the particular scrambling pattern shown in Figure 1 but they serve to illustrate the changing of this pattern as the beat frequency is changed. Thus, we have a simple means of varying the scrambling pattern. It is equivalent to changing the arrangement of 26 different connections by a single control.

Figure 2 and 3 show the different patterns that would be obtained with this machine if we had only 10 inputs. The top row of numbers represents the 10 oscillators and the bottom row the 10 receivers. The connecting lines show the effective paths of the radio waves or the equivalent connections. Starting with the arbitrary pattern labelled 1 on Figure 2 the scrambling patterns are shown that would result from changing the beat frequency by 10 steps of 10 KC each.

Going back to Figure 1, we find that the oscillators have frequencies ranging from 1.51 mc. to 1.760 mc. and of course the receivers must be tuned through this same range so that there is a receiver tuned to each oscillator. Now, when we decrease the beat frequency by 10 KC. (or one step) one receiver will be tuned 10 KC above this range and will thus not receive a signal. It is obvious that we must have two i.f. filters for this receiver tuned 260 KC. apart so that it will receive the correct signal. Similar reasoning shows that all receivers must have double i.f. filters to provide continuous operation through the cycle of patterns. It is equivalent to repeating the alphabet with 26 more receivers since the frequency of the last letter does not come out adjacent to the first.

The cycle of operation for the beat frequency oscillator follows a saw tooth pattern in which the frequency decreases by 26 steps and then flies back to the original pattern to start the cycle again. A rotating condenser plate stepped around by a pawl and ratchet, one step for each letter typed, provides a simple means of varying the beat frequency. There is an all electronic equivalent of this which would not have the limitation in speed imposed by mechanical action. It consists of a reactance tube connected to change the reactance of the tuned circuit of the beat frequency oscillator which tube is operated by an electronic counting stepping circuit, a number of forms of which are well known.

To set up the original pattern for the highest beat frequency one must set the tuning of the 2 X 26 i.f. filters. These filters may be of very simple form consisting of only a coil and condenser so that varying either the inductance or capacity serves to tune the filter. Mechanical coupling between the two components of a pair of filters is readily provided.

The oscillators would be very simple and could contain only one-half a vacuum tube each. That is, only 13 double triodes would be needed. Alternately, 26 transistor oscillators would suffice. For the receivers it might be possible to get by without vacuum tubes and to use two semiconductor diodes per receiver, one for modulation and one for detection. Alternately, one could use a single converter-diode vacuum tube for each receiver. The beat frequency oscillator would require only one or two vacuum tubes so that the total number of tubes or transistors would not be very large for the whole machine.

No provision would be needed for the paths of the radio waves. The coils of the tuned circuits could act as antennae and all of them could be enclosed in the same small shielded space for proper transmission between oscillators and receivers.

To further increase the secrecy of the coded message, several of these machines could be used in tandem with different scrambling patterns in each. For this type of operation the signals out of the receivers of the first machine would operate the oscillators of the next machine and only the receivers of the last machine would operate the printing type. The stepping of the beat frequency oscillators of all of the machines would be in synchronism.

For deciphering a message, the scrambling pattern of which was unknown, it would be of advantage to change the initial scrambling pattern at the start of each stepping cycle in a time that is short with respect to the time of one step or shift in beating oscillator frequency. This appears to be possible by providing the receivers with individual beat frequency oscillators which may be set to a pattern by 26 separate inputs and which are connected together so as to step together. The description of this machine requires another memorandum.

FIG. 1

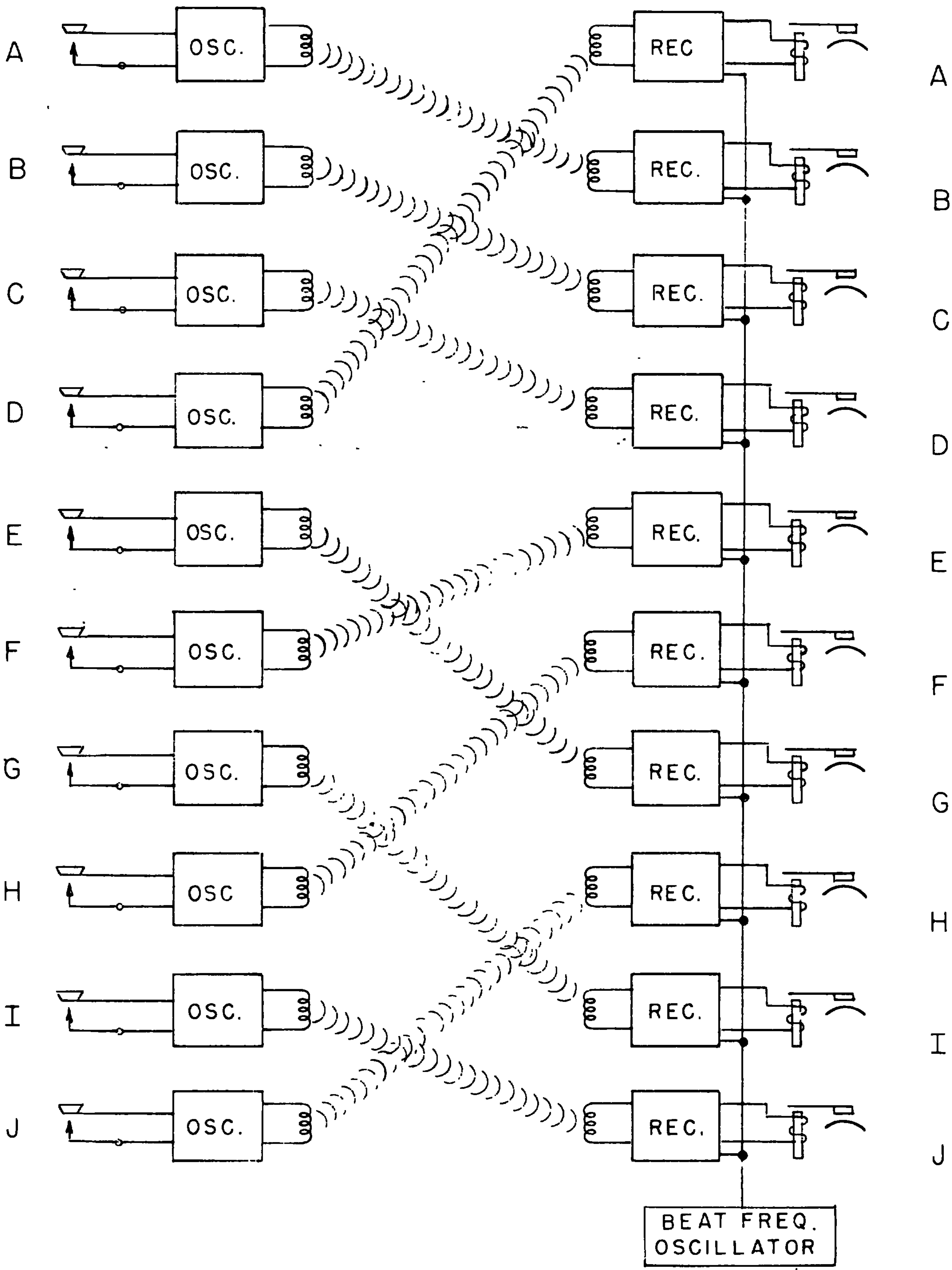

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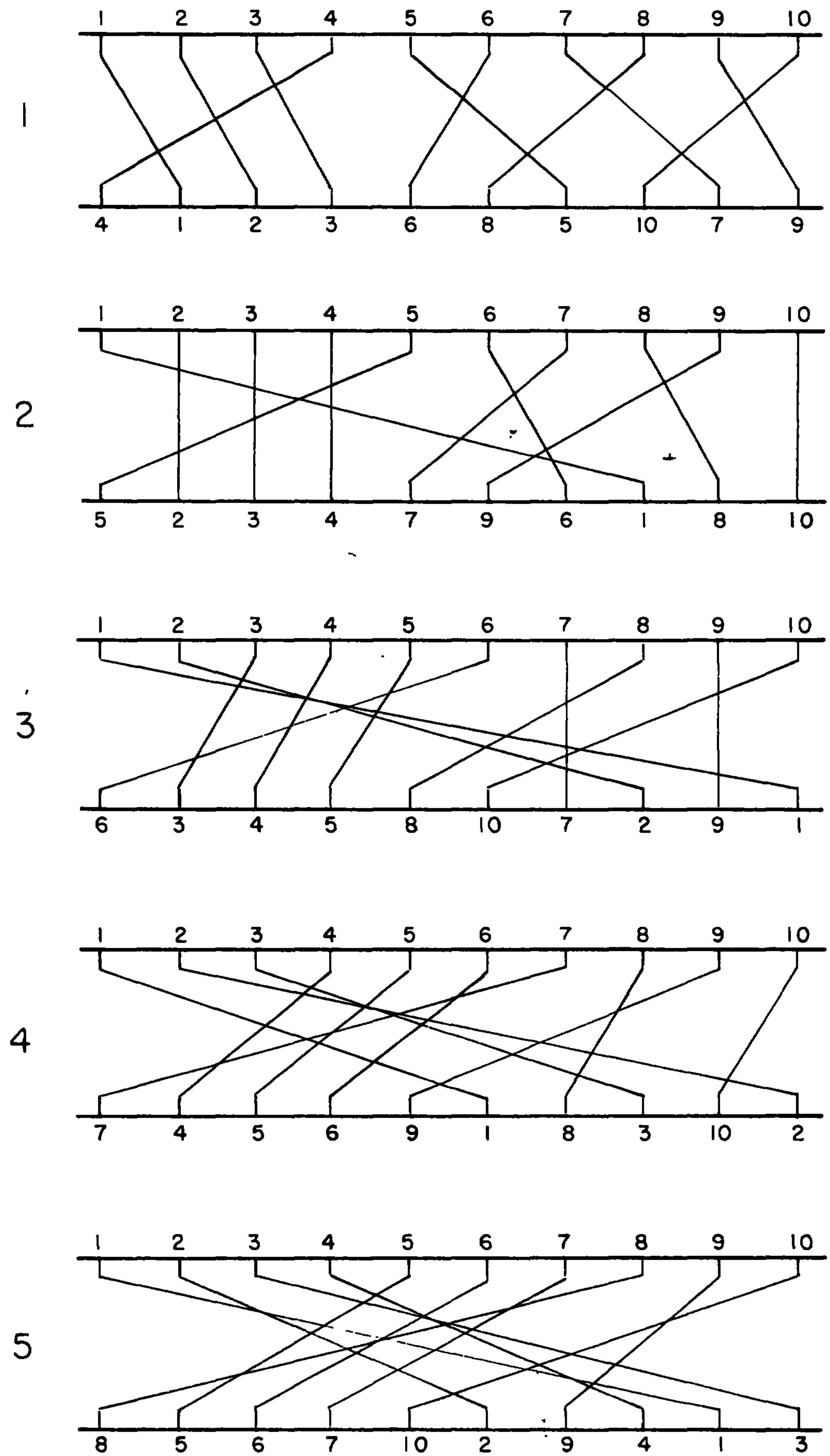
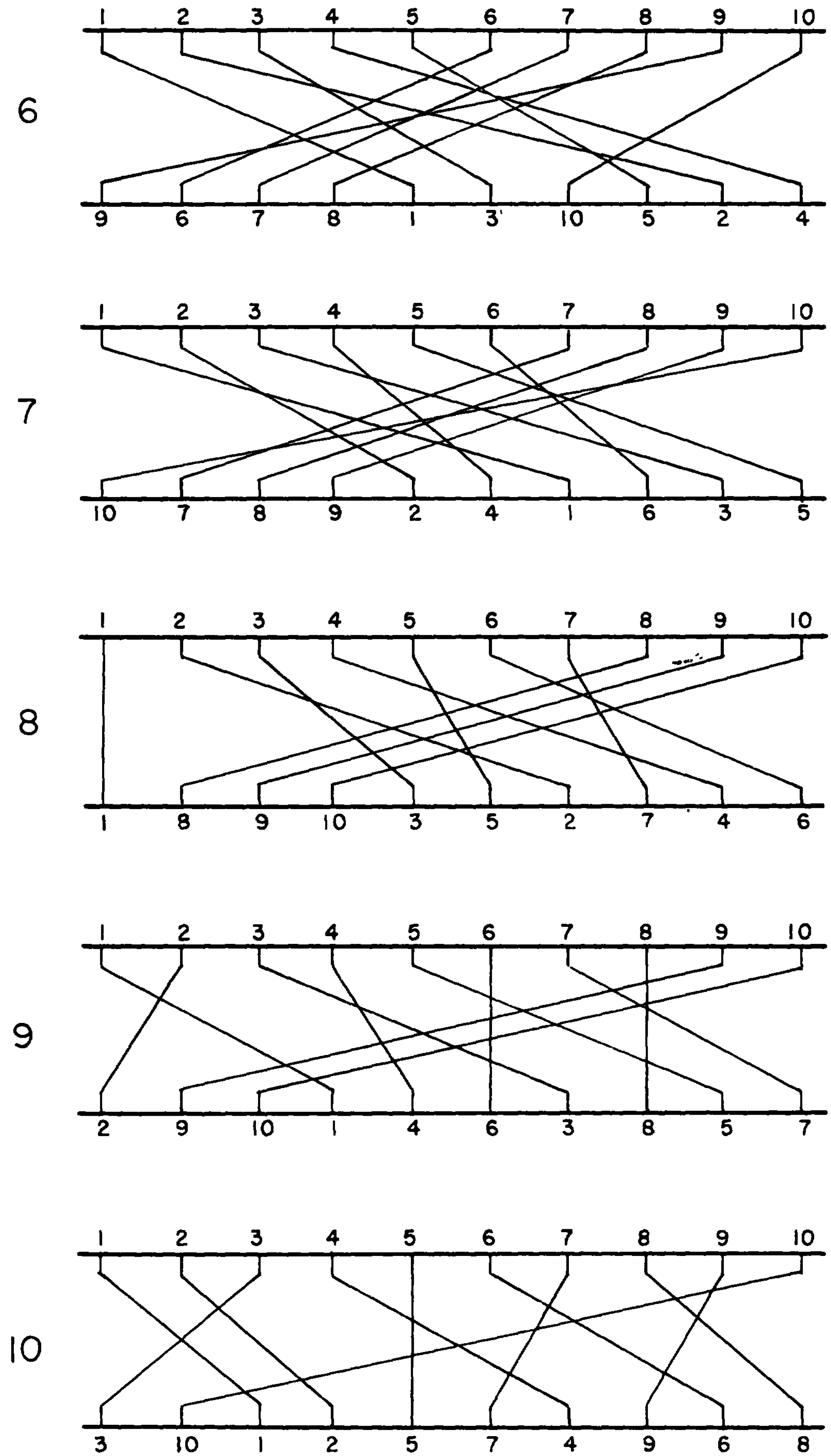
FIG. 2


1
1 2 3 4 5 6 7 8 9 10
4 1 2 3 6 8 5 10 7 9
2
1 2 3 4 5 6 7 8 9 10
5 2 3 4 7 9 6 1 8 10
3
1 2 3 4 5 6 7 8 9 10
6 3 4 5 8 10 7 2 9 1
4
1 2 3 4 5 6 7 8 9 10
7 4 5 6 9 1 8 3 10 2
5
1 2 3 4 5 6 7 8 9 10
8 5 6 7 10 2 9 4 1 3

A-1-5-125

FIG. 3


6
1 2 3 4 5 6 7 8 9 10
9 6 7 8 1 3 10 5 2 4
7
1 2 3 4 5 6 7 8 9 10
10 7 8 9 2 4 1 6 3 5
8
1 2 3 4 5 6 7 8 9 10
1 8 9 10 3 5 2 7 4 6
9
1 2 3 4 5 6 7 8 9 10
2 9 10 1 4 6 3 8 5 7
10
1 2 3 4 5 6 7 8 9 10
3 10 1 2 5 7 4 9 6 8

A-1-5-126

NATIONAL UNION ELECTRIC CORPORATION
350 SCOTLAND ROAD
ORANGE, NEW JERSEY

A. MELVIN SKELLETT
VICE PRESIDENT

September 20, 1954

National Security Agency
Department of Defense
Washington 25, D. C.

Attention: Dr. Howard H. Campaigne HC

Dear Dr. Campaign:

I am enclosing a description, in duplicate, of the machine that I talked to you about when I visited you last.

I never got around to telling you what a cordial reception I received at Corona and how profitable that I felt the trip was. Thank you for setting it up for me.

? There was a booklet that I requested from you which you will recall was not available for sending to me. I do not believe that I need that booklet now and suggest you cancel the request.

I will drop in and see you on my next trip to Washington.

With best personal regards

Yours very truly,

Mel Skellett

A. M. Skellett

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enclosures - 2