driven by 2 of the others in a similar manner. The procedure was not simple and required a great deal of hard work and clear thinking. However, I think the foregoing gives the principal steps involved in the solution and don't believe any more detailed explanation would be useful to you.

4. With respect to your paragraph 16, the April Codfish limitation was X2 + P5, as stated in Report #F 36. No ½2 limitation has ever been used on any traffic that has been read here. Was this, perhaps, a typographical error for X2 or ½1 or was there something in the traffic which made you suspect a ½2 limitation?

5. Mr. Newman was very pleased with the progress reported in paragraph 5. After you have proceeded as far as you intend to go with the traffic heretofore sent, I think it might be a good idea to let me know whether you think it feasible to try to assist with actual operations. I am thinking purely of rectangle analysis--at least until the IC film machine arrives. With patterns changing daily the volume of work to be done is beyond what can be handled here. Mr. Newman suggested this but before sending any current traffic he would want to know a bit more about the set-up there, that is, number of people available, whether they could work 3 shifts or only 1, IBM facilities available, etc.

6. I enclose photostat of write-up recently prepared by Mr. Newman's section on current practice in X setting, plus some theory. I am unable to understand the appendix but imagine it will be clear to some of our mathematicians. I hope soon to be able to send you some section write-ups on rectangle analysis.

7. Although very little Bream and almost no Jellyfish were read during July, a large volume of Tarpon was read and provided very valuable intelligence. Report #F 67 mentioned 4 Fuly Bream days solved. M37 of 20 July did have 27 dots as estimated. Only one additional Bream day has been solved, 26 July. The solution was statistical. The motor is not yet out but M37 is estimated to have 21 dots. Bream of 19 July has produced a significant rectangle which has not yet been analyzed. The same is true of Jellyfish of 17 July. The only Jellyfish day actually solved is 18 July which came out on the same Tarpon crib that solved Bream of the same day. M37 had 28 dots. It is now fairly definite that Codfish is no longer using Bream patterns. No time has been devoted to attempting an independent break of the Codfish wheels. Stickleback messages with identical QEP's fail to show the number of coincidences expected of true depths and therefore are undoubtedly using P5. No QTQNN messages have been found with identical QEP's. July

Gurnard has resisted all efforts at solution. This leads to the belief that patterns did not change daily but that M37 for the month had a very low number of dots. Grilse traffic has continued very light and no work has been done on it. Tarpon has been read through 29 July. It is suspected, from operators' chat, that a daily change of patterns is going into effect on this link as well.

8. A new method has been used to set a Tarpon message which could not be set statistically. It may prove useful for setting certain short messages but is of limited applicability because dependent upon a peculiarity of some of the July Tarpon X patterns. X2 and X3 consisted almost entirely of stretches such as xx..xx..xx..xx.. as a result of which d^2X was almost entirely cross for these wheels. The message was a "go-back," that is, the previous message had been broken off in the middle and was continued later with a different QEP. In such cases the operators frequently start the second message with a long stretch from the end of the first. Traffic analysis naturally plays an important part in finding these situations. Where the first of the pair of messages has been read, a crib is provided which has to be set at the beginning of the second. In a similar manner the first could be set from the second. There is little likelihood of a "go-back" long enough to permit the usual cribbing methods to be applied; however, with these unusual X2 and X3 patterns a more powerful method was available.

9. The theory of the method is not difficult but is most easily expressed in terms of "Proportional Bulge" or P.B. If the random probability is p and the non-random p(1 + L) then P.B. = L. For the case where p = 1/2, the P.B. is exactly twice what is ordinarily called the bulge, or excess over random. By using P.B.'s compound probability calculations are simplified. If an event a occurs whenever b and c both occur and whenever both fail to occur the P.B. of a is the product of the P.B.'s of b and c.

10. If a is the proportion of crosses in M_T then the proportions of pairs of motor impulses is approximately as follows:

..	$(1-a)^2$
xx	a^2
.x	$a(1-a)$
x.	$a(1-a)$

Let P.B.$(d\psi_1=x) = B_1$ Let P.B.$(d^2\psi_1=.) = \phi_1$

(1) Then P.B.$(d^2\psi_{1j}=.) = (1-a)^2 + 2a(1-a)B_1B_j + a^2\phi_1\phi_j$

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Let P.B.$(d^2X_1=x) = A_1$

(2) Then P.B.$(d^2K_{1j}=.) =$ (1) times A_1A_j

For July Tarpon

$a = 2/3$
$A_2 = .935$
$A_3 = .931$
$B_2 = .532$
$B_3 = .490$
$\phi_2 = .117$
$\phi_3 = .069$

Therefore, substituting in (2)

P.B.$(d^2K_{23}=.) = .202$

225 letters will give a bulge of just over 3σ. The tape is, of course, d^2P_{23} + d^2Z_{23}.

11. The foregoing describes a specific instance of what may become a much more general technique. A variety of statistical characteristics of known X patterns might be used in a similar fashion and if a number of independent tests can be found it will be possible to set messages where the overlapping stretch is much shorter.

12. The last sentence of paragraph 9 applies to the usual type of Tunny problem but is not universally true. b and c must be independent events and the random probability must be 1/2.

13. A modification of the ordinary cribbing technique involves looking at $(dZ_2 + dP_2 + \overline{P_5 \cdot P_4})$ at 5 different positions simultaneously and insisting that they all be identical. The positions must all be separated by intervals which are multiples of 31. The probability of positions 1, 32, 63, 94 and 125 being identical in the right position is $b^5 + (1-b)^5$ which, for $b = 2/3$, is 33/243, whereas in a wrong position the probability is only 1/16. The procedure for making and running tapes is known as "staircasing." This method apparently yields significant results with shorter cribs but since the distribution of the random cases does not follow the normal curve scores cannot be interpreted directly from tables of the normal probability integral.

Walter J. Fried
Capt. Signal Corps

Encl. - Photostats

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