REVIEW OF RATT WORKING

Radio Teletype (RATT)

Radio Teletype (RATT) is a method of transmitting information by means of a telegraph code, using automatic machines to produce the code, radio circuits to carry the information, and automatic machines at the receive terminal to reproduce the information in printed form.

Telegraphy has a number of inherent advantages over telephony, many of them being inter-related.

(a) Speed

Telegraph systems are faster than telephone systems, at least over the transmitted channel. This is because the message to be transmitted can be reduced to its simplest form before transmission. Further, a telephone link usually takes some time to establish and this is wasted time.

(b) Reliability

Telegraph systems are certainly more reliable than telephone systems and they can be made very much less susceptible to noise errors. A permanent record of the transmission can be made very easily, thus reducing the risk of human error in interpretation.

(c) Bandwidth

The bandwidth occupied by telegraphy is much smaller than that occupied by telephony. Alternatively, a number of telegraph channels can occupy the same bandwidth as one telephone channel.

(d) Cost

Telegraphy is usually much cheaper than telephony.

Disadvantages

Telegraphy has some disadvantages, the main ones being as follows:

(a) Lack of the "personal" aspect of a telephone system.

(b) Lack of a simultaneous two-way communication.

The Teleprinter

The Teleprinter may be regarded as an electric typewriter which in addition to producing a page copy will transmit the same copy to line in the form of electrical impulses. These electrical impulses form a standard international two condition code ('A' and 'Z') known as the Five Unit or Murray Code. Each character is made up of a particular combination of five elements all of equal length. Since the code has five elements and two conditions there is a total of $2^5 = 32$ possible combinations, and these are allotted to the 26 letters of the alphabet, and up to six functional keys. Two of the functional keys are the Letter Shift and Figure Shift keys which allow an additional 26 upper case characters to be used.

LOWER CASE	UPPER CASE 28	7B	12	CODE ELEMENTS 1	2	3	4	5
A	–	–	–	●	●	○	○	○
B	?	?	?	●	○	○	●	●
C	:	:	:	○	●	●	●	○
D	Ø			●	○	○	●	○
E	3	3	3	●	○	○	○	○
F	!	%	%	●	○	●	●	○
G	&	@	@	○	●	○	●	●
H		£	£	○	○	●	○	●
I	8	8	8	○	●	●	○	○
J	'	BELL	BELL	●	●	○	●	○
K	(	(	(	●	●	●	●	○
L	)	)	)	○	●	○	○	●
M	.	.	.	○	○	●	●	●
N	,	,	,	○	○	●	●	○
O	9	9	9	○	○	○	●	●

LOWER CASE	UPPER CASE 28	7B	12	CODE ELEMENTS 1	2	3	4	5
P	0	0	Ø	○	●	●	○	●
Q	1	1	1	●	●	●	○	●
R	4	4	4	○	●	○	●	○
S	BELL	'		●	○	●	○	○
T	5	5	5	○	○	○	○	●
U	7	7	7	●	●	●	○	○
V	;	=	=	○	●	●	●	●
W	2	2	2	●	●	○	○	●
X	/	/	/	●	○	●	●	●
Y	6	6	6	●	○	●	○	●
Z	"	+	+	●	○	○	○	●
CARRIAGE RET.				○	○	○	●	○
FIGURES				●	●	○	●	●
LETTERS				●	●	●	●	●
LINE FEED				○	●	○	○	○
SPACE				○	○	●	○	○

Diag. 6.1

The pulses transmitted to line may consist of:-

(a) a d.c. supply OFF for a 'Z' (Idle) condition, and ON for an 'A' (Active) (single current working),

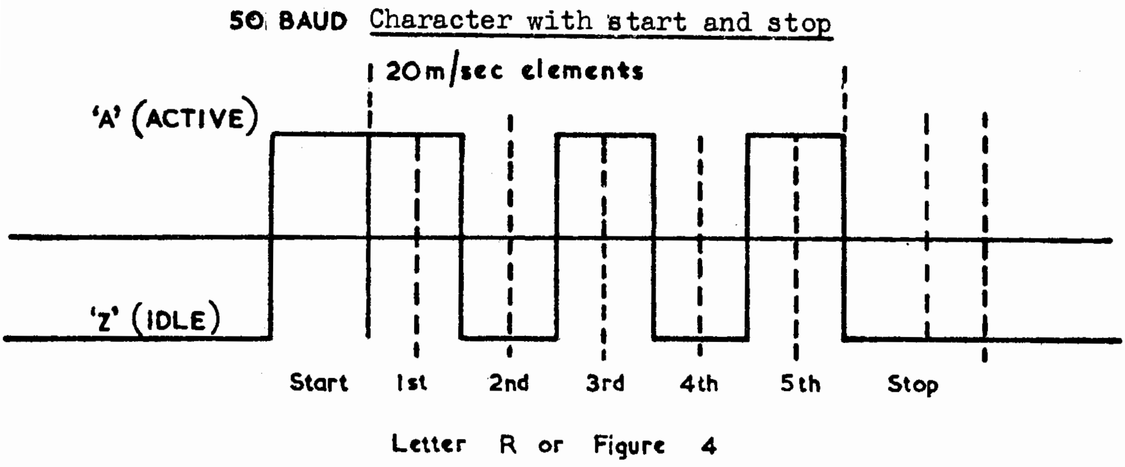
or

(b) a d.c. supply which has polarity reversed to distinguish between the 'Z' and 'A' condition (double current working).

Whichever method is used the d.c. changes produced by the operation of the keyboard may be used to key or modulate the transmitter of a RATT service.

After radio reception at the receive terminal the signal is converted into d.c. pulses to operate the printing mechanism of the receiving teleprinter.

In order to synchronise the send and receive teleprinters, each character is preceded by a Start signal of one element length (an A signal) and is followed by a Stop signal of one and a half Z elements. This arrangement is known as the "seven and a half unit start stop code".



Diag. 6.2

Associated items of equipment

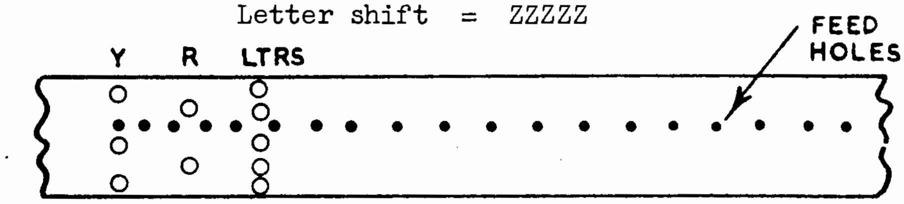
In order to make maximum use of available circuit time and to improve traffic handling, the following equipments are available:

(a) The perforator attachment. This is fitted to a teleprinter and produces a perforated tape in which a hole represents a Z and a blank an A,

e.g. Y = ZAZAZ

R = AZAZA

Letter shift = ZZZZZ



Diag. 6.3

(b) The auto transmitter. The perforated tape is passed through this machine which transmits it at the maximum operating speed of the circuit.

(c) The reperforator. An attachment fitted to a teleprinter and producing a perforated tape as a result of an incoming signal, the tape may be used for relaying via the auto transmitter of some other circuit.

Signalling Speed

This is expressed in Bauds. The baud may be defined as the number of shortest elements which may be transmitted in one second, e.g. for an element length of 20 milliseconds the signalling speed is 50 bauds (50 x 20 = 1000 m/secs).

Signalling speed in bauds may be equated with words per minute if the standard word is assumed to be sequence of six symbols, 5 characters, plus a word space. In the $7\frac{1}{2}$ element start stop code at 50 bauds each character has a duration of 150 milliseconds, therefore 6 symbols have a duration of 900 millisecs and hence the speed in words per minute is 66.6.

Telegraph Distortion

RATT systems can produce distortion at the receiving end for a variety of reasons. The effect is that the transitions from Idle (Z) to Active (A) and vice versa do not occur accurately at the 20 mS intervals (considering a 50 baud signal).

The distortion of a received teleprinter signal is the time by which any changeover is early or late with respect to its correct position (as measured from the first instant of the received start signal), expressed as a percentage of that unit signal element length.

Distortion may in general be of three kinds; fortuitous, bias and characteristic. Fortuitous distortion is of a random nature. Bias distortion may be caused by some asymmetry of the equipment or radio link. Characteristic distortion is caused by the transmitting equipment making a wrong or deformed element so that with any given combination of elements the same error is repeated consistently.

The selection instant of a Type 12 teleprinter is approximately the middle 6 mS of each element. Providing the transition occurs so that the element is correct during the selection time, the correct character will be printed. The distortion which a teleprinter will accept can be seen to be $\frac{7}{20} = 35\%$ early or late.

The total of the three forms of distortion mentioned is known as the cumulative distortion of the signal. A signal having Z bias in one link of a telegraph system and A bias in another could actually have less cumulative distortion at the distant receiving point than at points along the system.

Characteristic distortion cannot change anywhere in the system unless the signal is regenerated in some manner; whereas, fortuitous distortion will tend to increase with the number of links unless signal regeneration is employed.

Only by recognising these various forms of distortion separately can remedial action be carried out.

Synchronous systems have a marked advantage over start-stop systems in that the detection capabilities of synchronous systems are primarily determined by the accuracy of the synchronising devices, and the width of the pulse selecting the line signal condition (Z or A). If the selecting pulse is one per cent of the total signal pulse width then the receiving device can detect correctly up to forty-nine and a half per cent. There are systems capable of accomplishing this under controlled laboratory conditions. However, when the fortuitous distortion on a working circuit rises to a figure as high as this, the circuit is useless for all practical purposes.

CAUSES AND EFFECTS OF FORTUITOUS DISTORTION

Fortuitous distortion is practically uncontrollable unless the whole Tx/Rx system can be analysed. It is caused by signal line induction, atmospheric noise, power line induction, poor soldered joints, lightning storms, dirty keying contacts and similar random disturbances.

This type of distortion can only be minimised by properly engineering the system. Where a telegraph system consists of groups of equipment with links such as radio and landline facilities, a percentage breakdown of all distortion figures for each link or group should be known.

CAUSES AND EFFECTS OF BIAS DISTORTION

Bias distortion is a uniform lengthening and shortening of the 'Z' or 'A' element. If the Z is lengthened then the 'A' will be shortened by a similar amount.

Bias distortion can be corrected by adjustment of the equipment.

Causes of bias distortion are:-

(a) Maladjusted relays, causing the relay armature to hold longer on the A or Z contact.

(b) Receiver detuned, causing, say, the input to the discriminator of an f.s.t. converter to be unbalanced producing either Z or A bias.

It should be noted that any drift in the transmitter or receiver frequency control equipment will similarly unbalance the signal to the discriminator thus producing bias.

Bias distortion can be considered as effectively raising the signalling speed. The bandwidth occupied by the signal is largely determined by the speed of signalling. The faster the signalling speed, the greater the bandwidth. Thus, a system designed for 20 millisecond elements subjected to, say, Z bias of fifty per cent would have Z elements of 30 mS while the A elements would only be 10 mS. With this bias condition the signal is effectively twice as fast as the system is designed for. (The bandwidth required exceeds the bandwidth of the system and the signal is distorted.)

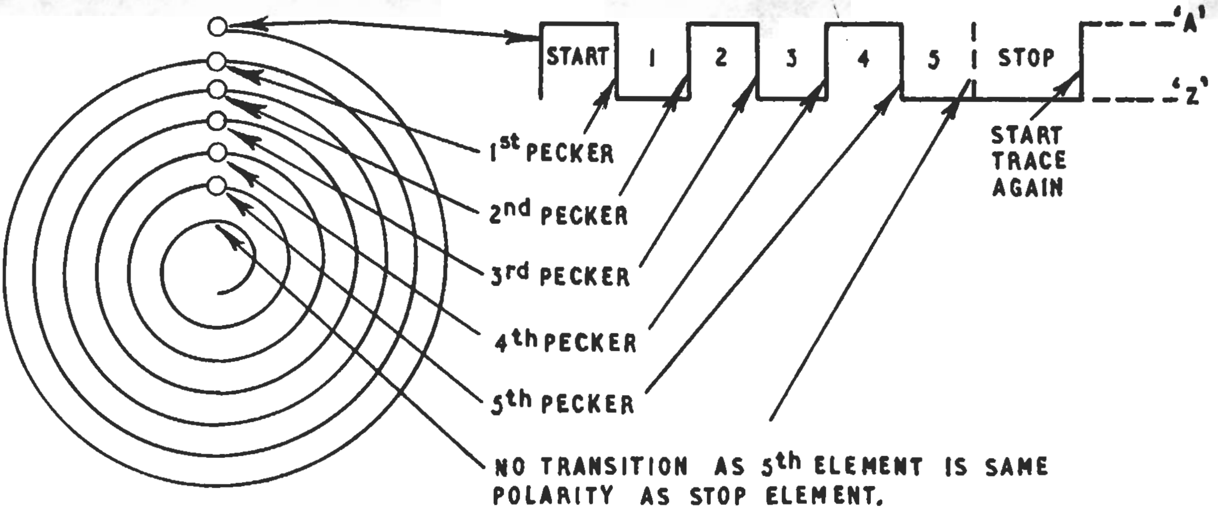
CAUSES AND EFFECTS OF CHARACTERISTIC DISTORTION

Characteristic distortion is "the repetitive displacement or disruption peculiar to specific elements of a character". It is normally caused by maladjusted or dirty contacts of the sending equipment. An example would be the repeated splitting of a particular element of a test character.

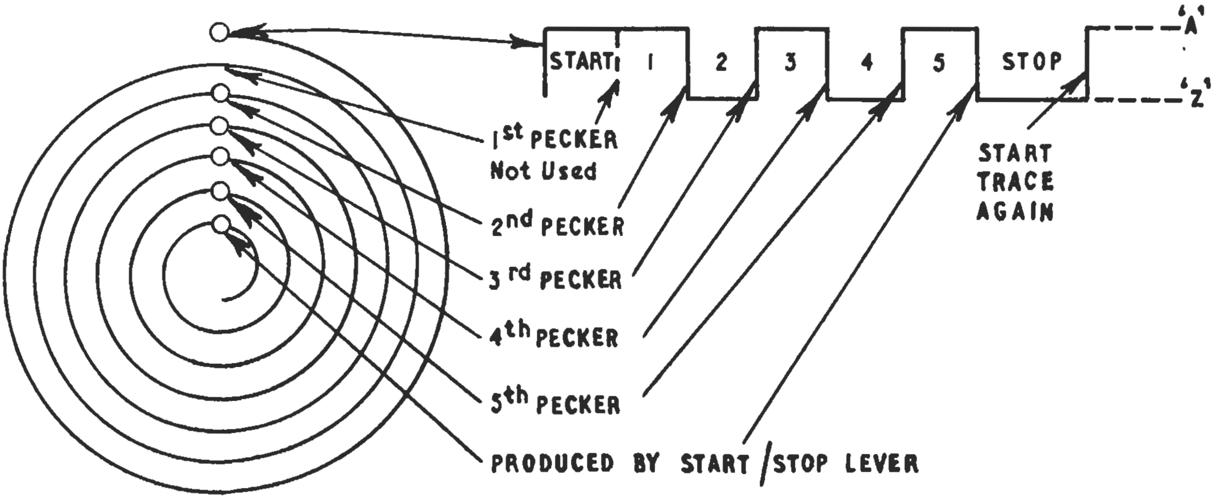
Analysis of Keying Waveforms

Analysis of RATT keying waveforms may be achieved by photographing the information displayed on an oscilloscope, and inspecting the developed film. This provides a permanent record and enables comparisons to be made. A cheaper, though transitory inspection may be made using a spiral oscilloscope trace, synchronised to commence with the first transition, and arranged to show as many spiral revolutions as there are elements in the character (e.g. the T.D.M.S.) Diagrams 6.4 and 6.5 show examples of $7\frac{1}{2}$ unit stop start characters, with the accompanying picture as displayed on a Transmission Distortion Measuring Set (T.D.M.S.).

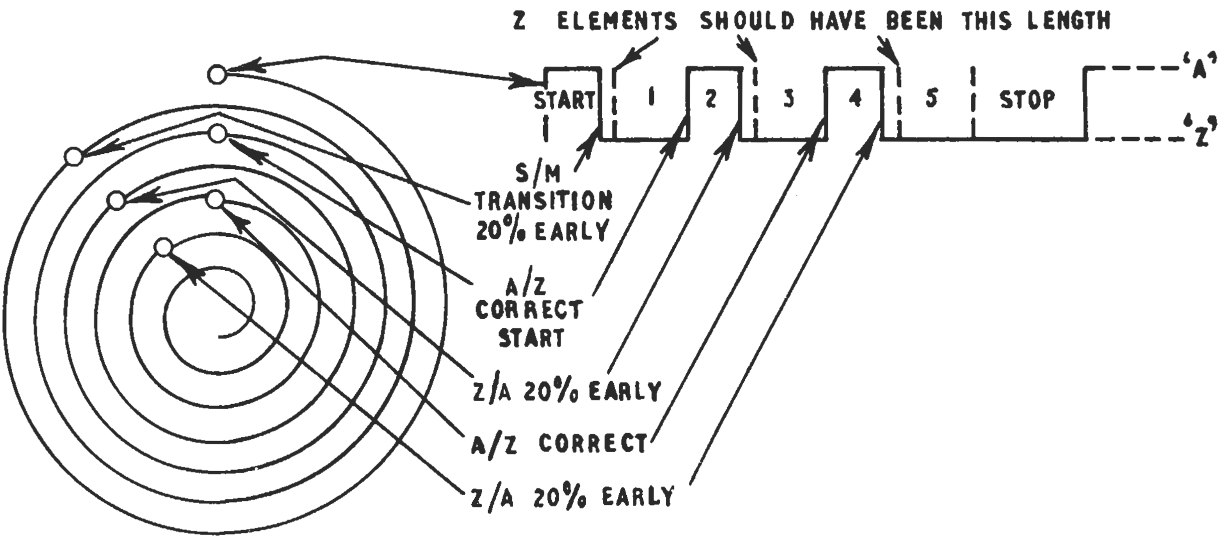
ANALYSIS OF TRACE — LETTER Y



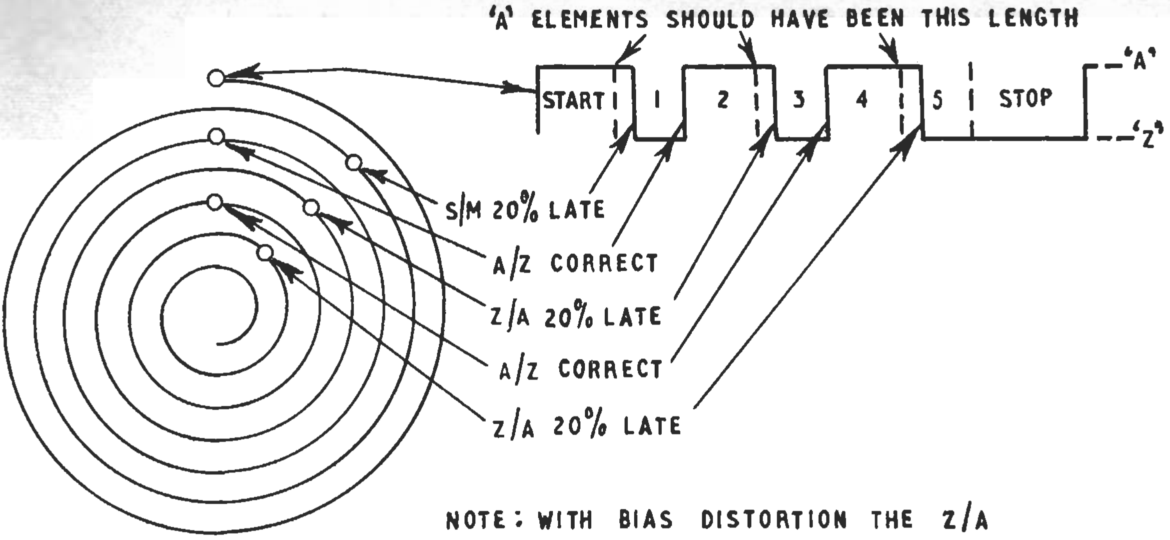
ANALYSIS OF TRACE — LETTER R



BIAS DISTORTION, 20% 'Z' — LETTER Y

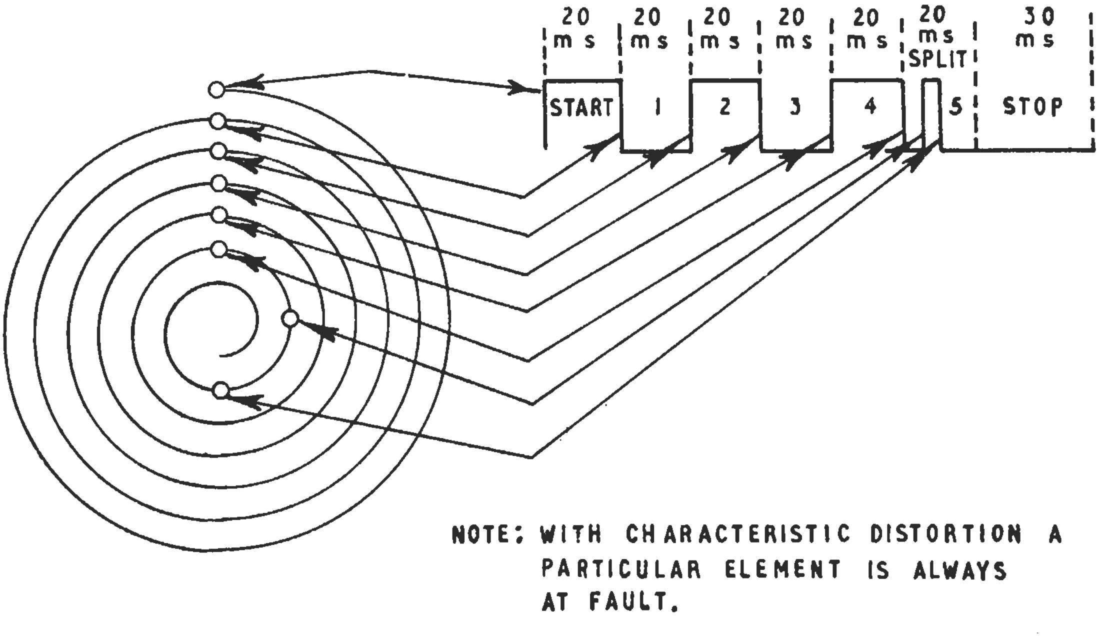


BIAS DISTORTION 20% 'A' — LETTER Y



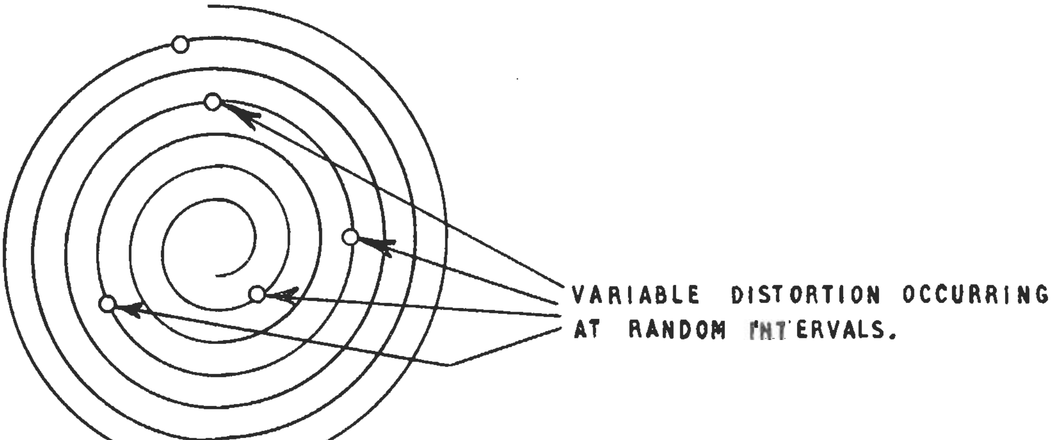
NOTE: WITH BIAS DISTORTION THE Z/A TRANSITION IS CORRECT IN TIMING.

CHARACTERISTIC DISTORTION — LETTER Y



NOTE: WITH CHARACTERISTIC DISTORTION A PARTICULAR ELEMENT IS ALWAYS AT FAULT.

FORTUITOUS DISTORTION



It should be realised that the engineering of a communication link does not apply only to the radio equipments, but also to the terminals and any intermediate points. For example, it is not sufficient just to ensure that the radio receiver is performing satisfactorily and not introducing distortion. Each link in the chain between aerial and terminal equipment - whether this be Teleprinter or Computer - must be examined in order to diagnose and eliminate any of the possible forms of distortion, thus ensuring that the signal arrives at its final destination with as few errors as possible.

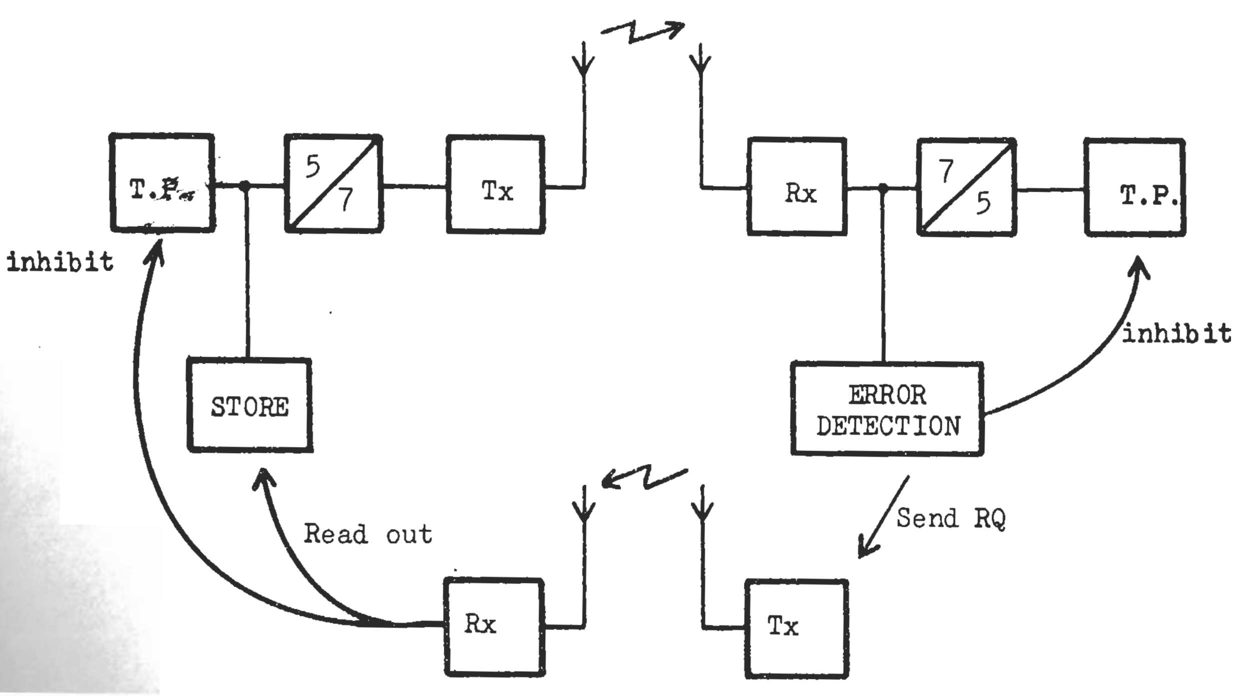
Protected Codes

In order to overcome the noise susceptibility of the 5-unit code, a 7-unit code was introduced. This is basically the same in principle as the 5-unit code, but it uses a sequence of 7 elements to represent each character. The code is normally employed in synchronous systems, hence start and stop signals are not included.

A total of $2^7 = 128$ permutations are possible, but only 35 of these are used to represent the characters and symbols of the alphabet. The code will therefore have a high redundancy and can thus be devised to combat noise effects. The 35 permutations employed are those having three "mark" or "Z" elements and four "space" (A) elements. Any departure from the 3:4 or Z:A ratio at the receiver will indicate an error. The three extra characters in this code represent continuous 'Z', continuous 'A' and 'RQ'.

This is the code used in the "return-path" type of automatic error connecting equipments. When an error is detected at the receiver at one end of the link due to an incorrect A:Z ratio, a request for a repeat is automatically sent to the other end (the RQ signal) via the return path. The input to, and the output from, such an equipment will generally be in standard non-synchronous five-unit code.

Code conversion is carried out in the equipment, the seven-unit code being employed for the transmission channel. In such a case the total duration of a character in seven-unit synchronous code will be the same as that in a five-unit non-synchronous code.



Assume that there is a path time delay of one element.

from store

Tx 1	A	B	C	D	E	F	RQ	C	D	E	F	G	H
Rx 1		P	Q	R	S	RQ	P	Q	R	S	T	U	V
Printer		P	Q	R	S						T	U	V

from store

Tx 2	P	Q	R	S	RQ	P	Q	R	S	T	U	V	W
Rx 2		A	B	?	D	E	F	RQ	C	D	E	F	G
Printer		A	B						C	D	E	F	G

It is possible that under very poor propagating conditions, the system could cycle and therefore no traffic can pass through. Under these circumstances, the operator can make the system indicate errors only.

The 'ARQ' system can only be used on a two-way system. On many systems there is a need to correct the received signal without having to ask the transmitter for a repeated signal.

It has been shown that the 5-unit code is non-redundant. The ARQ system uses a 7-unit code which can only indicate errors. 9 units are required to correct a single error. 10 units will correct a single error and detect a double error.

Consider a 10-unit code.

Here there is a five-unit character and a five-unit check character.

If the number of digits (1s.) in the original character is <u>odd</u>, the check character is repeated erect.

If the number of digits (1s.) in the original character is <u>even</u>, the check character is repeated inverted.

e.g.	1 1 0 0 1	1 1 0 0 1	odd number of digits and the check character is repeated erect
	1 0 0 0 1	0 1 1 1 0	even number of digits and the check character is inverted

If an error is received

Tx sends out	1 1 0 0 0	0 0 1 1 1
Rx	1 0 0 0 0	0 0 1 1 1

Error

The machine assumes an odd number of digits and therefore repeats the check character.

Original	1 0 0 0 0
Repeated check	0 0 1 1 1
	1 0 1 1 1

indicating an error.

Because the answer is (1s.) the check signal is in the wrong sense indicating an error in the first half or original character. The '0' indicates the error and the machine inverts this element and prints 11000, which is correct.

If there is an error in the check character,

Tx sends out	1 1 0 0 0	0 0 1 1 1
Rx	1 1 0 0 0	0 1 1 1 1

The even count of the original character ensures that the machine will invert the check character.

Original	1 1 0 0 0
Inverted check	1 0 0 0 0
	0 1 0 0 0

indicating an error.

Because the answer is in (0s.), the machine assumes the error in the check element and therefore prints the original 11000.

Double Errors

Tx	1 1 0 0 0	0 0 1 1 1	or	Tx	1 1 0 0 0	0 0 1 1 1
Rx	1 0 0 0 0	0 1 1 1 1		Rx	1 0 0 0 0	1 0 1 1 1

i.e. there is an error in both characters.

The machine assumes an odd count and repeats the check character.

Original	1 0 0 0 0	or	1 0 0 0 0
Repeat check	0 1 1 1 1		1 0 1 1 1
	1 1 1 1 1		0 0 1 1 1

Machine will print an error symbol for all (1s.) or for two errors.

If the signal is good,

i.e.	Tx	1 1 0 0 0	0 0 1 1 1
	Rx	1 1 0 0 0	0 0 1 1 1

the machine reads an even number of (1s.) and therefore inverts.

Original	1 1 0 0 0
Inverted check	1 1 0 0 0
	0 0 0 0 0

Machine will print the original character.