TELECOMMISSION

Study 8(b)(ii)

Interconnection Between TCTS and CN/CP Telecommunications

The Department of Communications

TELECOMMISSION Study 8(b)(ii)

INTERCONNECTION BETWEEN TCTS

and

CN/CP TELECOMMUNICATIONS

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Ottawa, 1971

This Report was prepared for the Department of Communications by a project team made up of representatives from various organizations and does not necessarily represent the views of the Department or of the federal Government, and no commitment for future action should be inferred from the recommendations of the participants.

This Report is to be considered as a background working paper and no effort has been made to edit it for uniformity of terminology with other studies.

PURPOSE

The purpose of this study is to examine carrier-to-carrier interconnections, including the TWX and Telex systems, to determine whether formulation of Government policy or legislation is required.

TERMS OF REFERENCE

The proposed terms of reference are:

1. What will happen if the Government takes no active role in the development of the system?

2. What would be the evolution of the systems which would best serve the public interest?

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TABLE OF CONTENTS

LIST OF FIGURES

APPENDICES

PART I INTRODUCTION

The study has been conducted on a broad base. An effort was made to determine the significance of the TWX-Telex systems in Canadian telecommunications technology. The relationships between these services and the developing Data transmission services were studied on the premise that TWX-Telex might be considered as low speed data systems with a future that was predictable according to how data systems might develop. This premise was found to be essential to an overview of the subject.

The question of interconnection between the two systems is reviewed, both from technical and service standpoints. The idea that these systems are a special case of the question of interconnections between the TCTS and the CN/CP Tel organizations is examined. It will be seen that this assumption does not materially contribute to the solution of the principal questions on interconnection. In fact the TWX-Telex question will be shown to be essentially a problem of another genre.

Considerable research and study were directed to the situation in the U.S., where acquisition of TWX by Western Union which operates Telex, is under way. Events in Canada often follow the U.S. leads. It was necessary to determine the basic reasons for the proposed merger in the U.S. and to draw accurate comparisons between the Canadian and U.S. situations. It will be seen that if Canada were to follow the U.S. lead it would be for somewhat different reasons. A definite impact of the U.S. action on Canada can be foreseen and it must be recognized as a factor in Canadian planning.

Brief studies were also made of developments in policy, planning and hardware in France, Great Britain and Germany. It was found that these nations, and West Germany in particular, appear to be several years ahead of Canada in some respects and in fact Governments of the Continental group and the U.S. have already assumed positions as a result of studies conducted since approximately 1965, and for which there appear to have been no parallels in Canada. A chart has been prepared forecasting the development of communications technology on a world basis using data from U.S. sources and the study of the European programs. Timing of corresponding developments in Canada will depend largely upon the expedition with which the necessary policy decisions can be made.

Since all recommendations can be expected to involve relations between DOC and the two principals, namely CN/CP and TCTS, it was considered necessary to briefly comment on the nature of these latter two organizations and to state certain assumptions with regard to their continuing status.

The subject of interconnection of all systems is dealt with separately in detail by papers submitted by the principals. An analytical discussion on these two papers has been added. Lastly, the concept of integration rather than interconnection (except for voice services) is discussed.

PART II DESCRIPTIONS OF TWX-TELEX SYSTEMS

2.1 Definition

The terms TWX and Telex are derived from 'teletype exchange'. Telex is the older service and is world wide. TWX originated with A.T.&T. in the U.S.

2.2 Terminal Devices

These devices perform the dual functions of message encoding and decoding as well as of functioning as signalling devices. In addition to a printing mechanism there is a signalling dial. The electromechanical printers in use have not changed radically over the years. Their characteristic disadvantages are the noise they generate and low speed. Various efforts have been made to improve them. The printers are associated with keyboards, typically 3 row for the low speed Baudot code Telex service and 4 row for 8 bit ASCII code for Data-Telex and all TWX services. The principal advantage recently has been in the introduction of the electronic keyboard. The keys in this unit are not mechanically linked to the typing mechanism as in the older models. Instead, they generate electrical signals which operate the printing mechanism and also the line output circuits. An example of these new keyboards is seen in the accompanying illustrations of new terminal equipment, ref Figs. 1*, 2.

Besides the basic manual input facilities noted, there are attachments available for automatic send and receive operation. For these purposes terminals are fitted with paper tape punches and/or readers. When TWX stations are operating into computers automatic

* The Siemens Model 150 is not in service in Canada at this time.

FIG-1

SIEMENS Teleprinter MODEL 150

5 level unit with electronic keyboard, paper tape and dial units. Used for Telex.

FIG-2

TELETYPE CORP., Teletype Model 33 ASR

8 level code, with paper tape and dial as used for TWX

send and receive terminals are important to system utilization.

Teletype terminals employed in the two systems have few distinguishing external characteristics. An important difference is that TWX terminals require a modem to convert the keyboard output to the tone signals which are the transmission media. The unit manufactured by Northern Electric is illustrated in Fig. 3. The modem approximately doubles the cost of the basic manual input TWX terminal over the similar Telex unit, however this is offset in the Telex system by the cost of multiplexing equipment which is not required by TWX.*

In their Telex applications Canadian National and Canadian Pacific Telecommunications employ a variety of teleprinter and terminal equipment. On the 50 baud general Telex network the most commonly used are Teletype Corporation's Model 32, Model 28 and Lorenz Model 15 machines. On the Data-Telex networks where the speed (up to approximately 180 bauds) and the code are nonrestrictive there is a wide choice of terminal equipment such as the IBM 1050 machine and Teletype Corporation's Model 33 or 35 dependent on the customer's requirement. The new Siemens Model 200 is illustrated in Fig. 4.**

Principal suppliers of equipment to the Canadian systems have been Siemens (Germany) and the Teletype Corporation (U.S.). Until recently tooling and other costs compared to the market made it uneconomical to attempt production in Canada. Factory level repair and overhaul facilities are maintained by CN/CP for their equipment.

* Telex retains an advantage as the multiplexing is not required at each terminal.

** Not in service in Canada at this time.

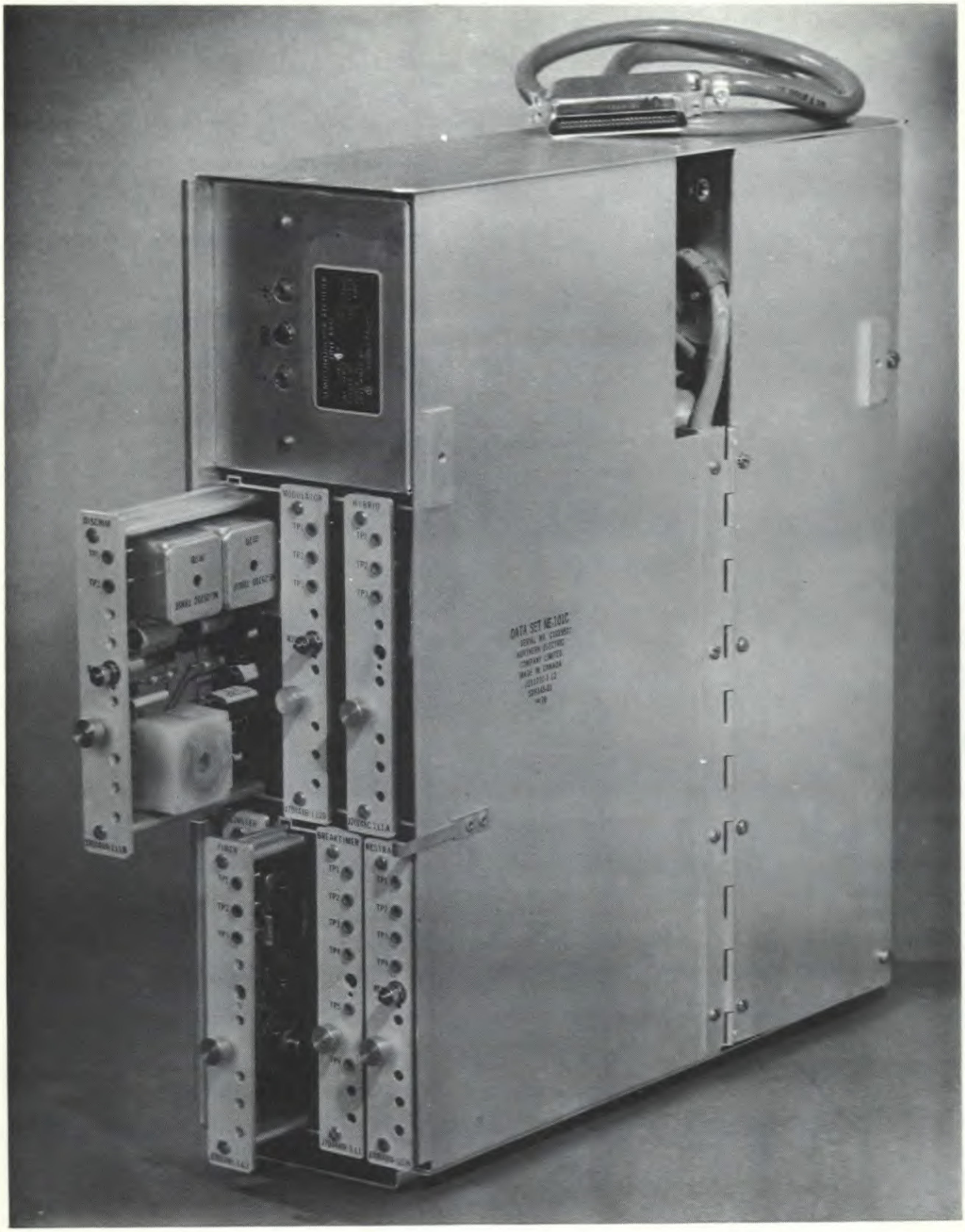


FIG-3

NORTHERN ELECTRIC Data Set 101C,
Modem for TWX service

FIG-4

SIEMENS Model 200 Teleprinter

Operates up to 200 Bauds, 8 level
code, with paper tape and dial.
Designed for DATA-TELEX, etc.

that the Teletype Corporation is considering licensing a Canadian company to supply maintenance, and for repair and overhaul facilities.

2.2.1 Future Developments - Computers within the system as in the proposed TELENET service are revitalizing the systems to provide better, faster service and fuller utilization, however no corresponding changes have been made in terminals which limit the speed of TWX and Telex services. Both the manual keyboard, and the paper tape feed currently used for automatic send and receive are low speed data devices. Siemens and many other suppliers offer a versatile electronic display system, Model 1850 Data Display Terminal, which is illustrated in Fig. 5. This unit operates at 1200-2400 b/sec. It would be technically quite feasible for a subscriber to ask for a display terminal such as this, which is noiseless and could be conveniently located in a private office with a printer remotely connected in a loop. It is a question of market demand. Introduction of such devices into the business office as a computer service will probably result in a demand for its use in regular message service. Other developments include modems which incorporate delay line memories to serve as buffer storage to assist the system designer in accommodating busy signal, or priority message situations.

It is generally considered that as with the telephone service which will be complemented but not displaced by videophone service, there will continue to be a demand for low speed teletype services. As business usage grows and the networks become more complicated the great pressure will be to improve system utilization by

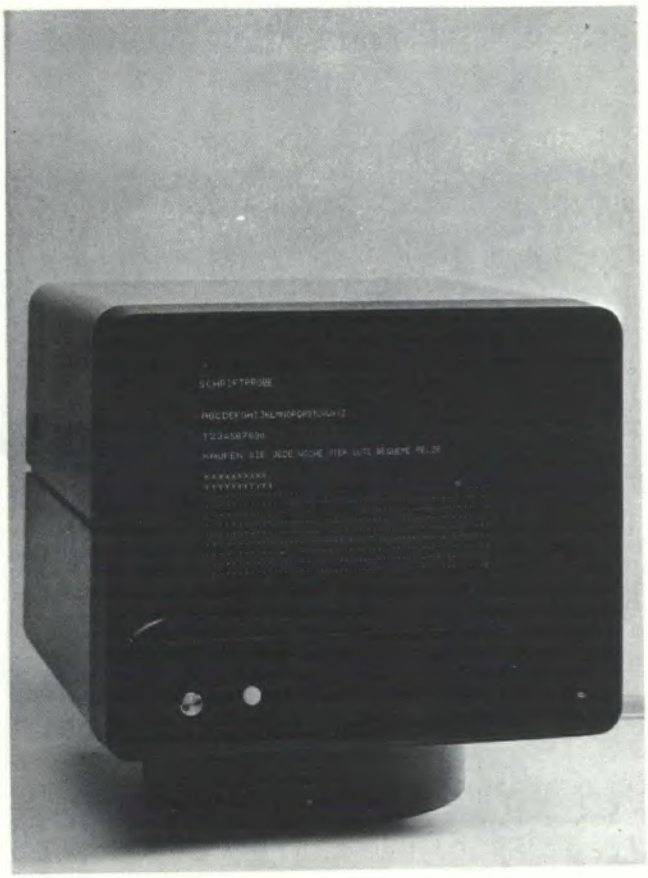


FIG-5

SIEMENS Model 1850

Electronic DATA Display

Has associated 5 row keyboard central unit, 64 characters. Operates on ASCII at 1200 or 2400 b/s. Data Teleprinter 200 can be connected to the control unit to furnish hard copy.

greater technical efficiency and by off-peak load services. System capacity will increase for storing messages of a low priority nature so that they can be transmitted at night or during off-peak periods. Such storage of course is a facility associated with every computer central processor. Maximum efficiency in use of such storage requires high transmission speeds. We can expect the TWX-Telex services to eventually employ a range of transmission speeds. Truly high-speed data transfer on a general random access basis probably will require entirely new plant, designed for digital transmission, not just modified voice frequency services.

2.3 Telex System Description

2.3.1 General - The system consists basically of automatic switching equipment, trunk circuits interconnecting these various exchanges, subscribers' teleprinter equipment with the exchanges.

The Canadian Telex system is a public automatic exchange network which is composed of a three level hierarchy of exchanges:

1. Junction Exchanges
2. District Exchanges
3. Sub-District Exchanges and Concentrators.

International Telex calls to the United States and Mexico are made via Western Union facilities and overseas calls via Canadian Overseas Telecommunications Corporation facilities. At present, international gateway exchanges to the United States are located at:

Vancouver which is connected to Western Union San Francisco

Winnipeg which is connected to Western Union Chicago.

Toronto which is connected to Western Union Chicago.

Montreal which is connected to Western Union New York.

Overseas connections are made via COTC at Vancouver (to be phased out August 13, 1971) and Montreal.

The signals on the general Telex network are at a rate of 50 bauds, are a synchronous (start-stop) and use the 5 unit code (7.42 elements per character including a stop pulse of 1.42). CCITT keyboard and alphabet (international code No. 2) are employed throughout the system. The subscribers' station is equipped with a control unit, incorporating a dial plate, a page printer and, if requested, a tape perforator and tape transmitter.

For customers requiring higher speeds, up to approximately 180 bauds, a network, designated Data-Telex, is provided using appropriate trunks. Basically, it is very similar to the 50-baud general telex network so far as the exchange equipment and network layout are concerned but any code and any speed up to 180 bauds may be used depending on the customer's requirement. Up to nine Telex circuits can be derived from one standard voice channel. Customers of the Data-Telex network are not provided with a directory, and cannot generally communicate with standard Telex network customers. This is principally due to incompatible terminals. However, arrangements can be made upon demand to effect intercommunications.

2.3.2 Layout of Network - Junction exchanges are all directly interconnected with one another (Fig.1)* to provide direct access between them, (and are located with a geographical and economic point of view). Their main function is to provide a connection between district networks either in their own areas or the areas of other junction exchanges.

All District exchanges are connected radially to parent junction exchanges (Fig.1),* (within the geographical area of that junction exchange). District exchanges are not directly interconnected, but are connected only to junction exchanges with calls between District exchanges being established through junction exchanges. District exchanges serve as the connecting link to the subscribers.

Sub-exchanges may be considered as satellites of District exchanges. They are remotely located from the District offices and serve as the connecting link to the subscribers in a particular area. All connections to the subscriber on sub-exchanges are made through District exchanges.

2.3.3 Numbering Scheme - An open numbering scheme is employed. Each junction office (Area Office) is assigned a number: i.e. Montreal 01 and 05; Toronto 02 and 06; Winnipeg 03 and 07 and Vancouver 04. The digit 0 indicates that the call must be switched through one of the junction offices (long distance). The area digit that follows indicate which junction office (or area) is required.

* Appendix A

Identification of District Office to which a subscriber is assigned is by the third digit:

Example: 037

0 - indicates long distance

3 - indicates Winnipeg Junction (Area) Office

7 - indicates the Edmonton District Office.

Sub-exchange offices are designated by the fourth digit. It should be noted that the fourth digit is not isolated to sub-exchange only but could represent as well for example a Local Subscriber group in the District Office. The last two digits provide the subscribers number.

Example: (1) 037 2185

037 - Edmonton District Exchange

2 - 1000 group - Edmonton

1 - 100 group - Edmonton

85 - subscriber's private number.

(2) 037-5185

037 - Edmonton District Exchange

5 - Peace River (Sub-Exchange)

1 - 100 Group Peace River

85 - Subscriber's private number.

For Telex calls to the United States, preliminary digits "00" (zero-zero) followed by the subscriber's complete number as listed in the Western Union directory will provide access to the Western Union subscribers. Telex service to countries other than the United States is supplied by the International carrier switchboard facilities at Montreal (COTC) and Vancouver (COTC). Access to the "Overseas operator" is made by dialling the gateway junction office at Montreal or Vancouver followed by digits "00". (Example 0100, 0400). After establishing connection to the "overseas operator" the destination code and overseas subscribers number are typed on the keyboard. Complete instructions for international calls are contained in the Canadian Telex Directory.

2.3.4 Technical Characteristics - All exchange equipment in the Canadian Telex network has been purchased from Siemens Halske* in Germany. In recent years Canadian National and Canadian Pacific Telecommunications have purchased from Siemens a new and more sophisticated type of Telex exchange system known as TWK. These new exchanges are designed to be compatible with the electro-mechanical step-by-step TW39 systems initially provided by Siemens Halske. For the purpose of this presentation, a brief description of both systems will be provided.

The TW39 Automatic Teleprinter Exchange system is an automatic switching system operating on the dial switch selection principles, i.e. the subscribers establish the desired connection themselves by simply operating a dial switch provided on the subscriber machine.

* Now "Siemens" which have a Canadian facility.

The various selection stages of the system are provided with rotary stepping switches and two-motion stepping switches. The rotary switches are used in the preselector stage facing the subscriber while the 100 outlet two-motion switches are in the group and final selector stages. The group and final selectors are directly controlled by the selection information transmitted by the subscribers in the form of dial pulses. The number of selection stages is dependent on the size and type of exchange (i.e. junction, district or sub-exchange). (Fig.2,3,4)*

The TWK system uses COMMON CONTROL facilities and Relay Matrices to perform its switching functions. Its notable features are not only its compact constructional design and the use of ESK relays in its switching matrices but also its programmed functions which closely resemble those of a computer. The basic model of the TWK teleprinter exchange performs the same functions as the step by step TW39 systems. Connections are established by way of a three stage link network operating with ESK relays which are used in place of selector switches.

Dial pulses are stored and the dialed information is decoded and read into the common control for corresponding control instructions. The subscriber stations are connected to line terminating sets within the Exchange. Each line terminating set may be circuited for mode-of-operation, subscriber category, and other

* Appendix A

criteria by proper programming. The TWK exchanges in Canada are designated as TWK-2, and TWK-8. The principles of operation of the different models of TWK exchanges are basically the same but differ in capacity and special features which will be considered unimportant for this presentation. (Fig. 5)

The same principle has been further developed in such a way that it is suitable for tandem exchanges where trunk lines only are interconnected. These exchanges are designated as TWK-D exchanges and are being installed in the junction offices across the system. Although used as a junction exchange at present, it should be noted that the TWK-D can be employed as a District exchange. Subscribers cannot be connected directly to a TWK-D exchange.

General requirements of the system and component exchanges include:

System should cater to the subscribers' offered load with an overall grade of service of 1 in 100. (The case of called-subscriber-busy is excluded). Lost call rate through individual switching stages is 1 in 1000.

Automatic Time Zone metering is performed at originating exchanges to enable charging a subscribers in accordance with the distance and duration of a call. "Free of Charge" calls, e.g. to Information positions, telegram message positions, International switchboards, etc., are provided.

Selector stages respond to dial-pulse trains conforming to CCITT recommendations (i.e. 40/60 milliseconds make-break).

2.3.5 Signal Facilities - Siemens Telex Exchange equipment provides the following facilities:

(a) A revertive pulse is transmitted from a distant exchange upon seizure of a trunk to that exchange.

(b) A free line signal of at least 800 MS marking is transmitted from the called exchange to signify to the calling exchange that the called subscriber's machine has started and so that charge timing of the call can commence.

(c) A cyclic busy signal of 200 MS marking followed immediately by 1.2 second spacing is transmitted under the following circumstances:

- When the called subscriber is busy.
- When all available intra-exchange trunks between switching stages are busy.

- If a subscriber fails to dial or to complete dialling.
- When a cancelled number is dialled.

(d) The TW39 and TWK-D exchange uses CCITT type "B" signalling and can be interconnected with exchanges of any type employing the same signalling scheme.

2.3.6 Time Zone Metering - The Time Zone Meter equipment as part of the exchange equipment is required for automatically charging the subscriber for his call. This equipment has been designed to accept and evaluate the first four digits as it monitors the line.

Fourteen pulse rates are currently employed. An appropriate pulse would be applied to the subscribers meter but only when the called party has been reached successfully.

The Time Zone Meter is seized and held by the originating subscriber for the duration of the call.

Modifications to the charge rates are conveniently carried out by the use of strapping on the TW39 equipment and by programming on the TWK equipment.

In TW39 exchanges the charge meters may be associated with the line terminating sets, but it is preferable to arrange all meters centrally located on a separate rack. With TWK-2/8 exchanges this is the standard arrangement.

2.3.7 Pulse Generator - The pulse generator, part of the exchange equipment, is required to apply selected rates of metering pulses to the subscribers charge meter. Aside from generating metering pulses, however, the pulse generator provides pulses used in alarm delay circuits. It is possible, for example, that the 1 ppm rate could be used to control alarm relays associated with equipment racks.

Generation of metering pulses may be by electro-mechanical or electronic means. These pulse rates are: 1, 2, 3, 4, 5, 6, 7.5, 8, 10, 12, 15, 18, 22, 24, 30, 36, 40, 45, 60, 72, 90, 120, 180, 360 pulses per minute. They are of square waveform and a length of 65-90 milliseconds negative 60 volts. The pulse output must be grounded in the period between each pulse.

This output is also monitored so that a disconnection, permanent grounding or short circuit affecting the output of any pulse lead will be indicated immediately in the form of an urgent alarm. This alarm also indicates ineffectiveness of a pulse caused by loss of power or severe distortion, for example. (Not part of TWK-2/8 exchanges.)

2.3.8 Subscriber Equipment - All Telex subscriber equipment is connected to a Telex exchange circuit by way of a remote control unit. The remote control unit varies considerably in design depending on manufacturer and teleprinter employed. Certain teleprinters have inbuilt solid state control units while others require the addition of these units. In spite of the differences of designs, all remote control units are required to perform certain basic functions.

The remote control unit will automatically connect the teleprinter upon the arrival of a call without the need of an attendant. It contains all the control elements and electrical switching means required for setting up or clearing a connection. These include the dial switch, a calling and clearing key, a visual indicator which, after the calling key has been depressed, indicates when dialling can begin and finally an indicator light which remains illuminated as long as the motor of the teleprinter is running and the teleprinter is engaged. In addition to the above control elements, some remote control units of special design permit local loop operation. This feature allows the teleprinter to be used for typing practice or preparing perforated tape when the teleprinter is equipped with a reperforator unit. When the teleprinter is in this mode its ability to receive calls is not impaired as all incoming calls take priority over any local operations, thus a buzzer will sound for approximately 3 seconds after which the teleprinter will be switched automatically from local to exchange operation.

The Telex subscriber is normally connected to the Telex exchange via a 2-wire circuit. This circuit operates on either a 40 or 60 milliampere closed current and connects the subscriber on a half duplex basis (two-wire local). In the event the connecting circuit between the subscriber and the exchange is too long and either the 40 or 60 milliampere loop current cannot be sustained, the subscriber must be connected to exchange as a long distance subscriber.

In the long distance configuration the mode of the teleprinter itself remains the same as with a local subscriber except that a device known as either a polar adapter or d.c. converter is introduced at the point where the exchange loop meets the teleprinter. With this device the operating current is usually reduced to 20 milliamperes and the operation is in the polar mode which is more suitable for transmission over long distances. For moderately long distances polar transmission can take place over physical transmission facilities. However, in cases where a subscriber is located a great distance from a Telex exchange a voice frequency telegraph channel may be required as the medium. Each Telex subscriber connection is carefully evaluated and the correct circuit configuration is designed and implemented for optimum transmission quality.

2.3.9 Trunk Facilities - Telex exchanges are interconnected by voice frequency carrier telegraph channels. In general the majority of VFCT systems on the Canadian Telex network employ the frequency shift modulation technique which is considered superior in performance to the amplitude-modulation systems. The amplitude-modulation VFCT systems are still existent in the network but are gradually being replaced.

On the 50 baud general Telex network, VFCT channels are spaced at 170 Hz. Depending on the bandwidth of the available voice path, it is possible to provide up to 18 VFCT channels. For higher speeds up to 180 baud, VFCT channels spaced at 240 Hz are provided. Fig. 7* illustrates the standard frequency spectrum of these channels.

2.4 Tel-Tex Service

In this service the customer may get a message through to a non-subscriber by dialing the nearest telegraph company terminal in the Telex network using a special code. An operator at the terminal takes the message and gives it the same service as is offered for telegrams i.e. telephone call to destination followed by mail service or on occasion direct delivery. The normal Telex rate plus a flat fee of $1.00 is charged. The service is available in approximately 110 cities plus 1,000 small communities. This system considerably extends the coverage of the Telex system although it does so by adding a time-delay.

2.5 TELENET Service

TELENET is a pay-as-you-use CP/CN general service

* Appendix A

offering providing a computer-oriented store-and-forward message switching service for the medium size communications user. The system is controlled by Philips DS-714 computers located in Montreal and Toronto. Customer service is planned early in the first quarter of 1971.

Each subscriber network is private. The exchange of messages, between networks via the computer, is prohibited by computer program, at least in the initial offering.

Subscriber network stations are categorized into three classes of service dependent upon volume of traffic or the grade of service required.

Class A is a heavy volume station provided with a dedicated circuit and a dedicated computer port. A Class A circuit may have more than one station, provided the stations belong to the same network.

Class B is a medium volume station provided with computer access circuits via the Telex or the Data-Telex networks. Computer ports are shared. The station is equipped for Telex operation and has access to and from the regular subscribers of Telex or Data-Telex.

Class C is a light volume station similar to Class B.

Stations are provided with teleprinter equipment operating initially up to 100 wpm in either 5 or 8 level codes, as applicable. Individual network circuits may be any code or speed. Speed conversion and code translation is provided by the computer.

A billing program in the computer records character usage for those network charges based on usage rather than fixed charges.

Group address and book message capability is provided. Each message sent by a station is individually accepted or rejected by a computer-generated notice. Message retrieval is possible up to three months.

Subsequent phases will offer high-speed data handling capability, interface with customer-owned computer, and message refile.

2.6 Telex Economics

2.6.1 Investment and Revenue - Capital investment figures for the Telex system are not readily available. CPR which capitalize Telex switching, trunking and subscriber station equipment in separate accounts, show new capital expenditure up to the end of 1969 to be $29,500,000 and supplement this with the statement that this does not include the capital value of microwave channels nor the value of existing plant utilized in Telex service. With the CN, the situation is complicated by the admixture of telegraph trunk costs. Their investment in Telex, Broadband, and subscribers equipment totals $51,000,000 approximately. This is exclusive of microwave or other long line facilities. The total CN/CP capital investment in telecommunications plant currently is $430,000,000 approximately, of which the major share rests with CN Telecommunications.

As a means of comparing the scale of the investment with other countries we note the following.

CN/CP Tel, Telex terminals in Canada -	20,000	subscribers *
USA	32,000	"
West Germany	70,000	"

Gross joint revenues from Telex for the past four years were:

Year	Amount $	% Increase
1966	17,546,000	
1967	20,664,000	17.5
1968	25,178,000	22.0
1969	29,804,000	19.0

2.6.2 Subscriber statistics - Coverage of the Telex network is summarized in the following tables. These refer to 1970 levels. The first table is of 50 baud domestic Telex terminals. The second is of the Data-Telex system. The number of terminals is said to be increasing at the rate of 15% annually.

* capacity 29000

Coverage - Subscriber Lines

50 BAUD NETWORK

Province & City	Qty.
NEWFOUNDLAND	
St. John's	410
Cornerbrook	140
Gander	50
Grand Falls	100
Goose Bay, Lab.	110
NOVA SCOTIA	
Halifax	550
Kentville	90
Yarmouth	50
Amherst	20
Truro	50
Port Hawkesbury	20
New Glasgow	100
PRINCE EDWARD ISLAND	
Charlottetown	100
Summerside	50
NEW BRUNSWICK	
Saint John	230
Fredericton	150
Woodstock	50
Moncton	310
Edmunston	20
Campbellton	100
Bathurst	50
QUEBEC	
Montreal	3520
Granby	20
Drummondville	20
Thetford Mines	20
Trois Rivieres	80
Sherbrooke	80
Ste. Thérèse	20
Quebec	460
Noranda	50
Val d'Or	50
Senneterre	100
Roberval	20
Chicoutimi	120
Riviere du Loup	20

Province & City	Qty.
QUEBEC (Continued)	
Pointe Claire	200
St. Jean	50
St. Georges de Beauce	50
ONTARIO	
Ottawa	740
Pembroke	40
Renfrew	20
Peterboro	60
Cornwall	50
Toronto	3840
Cooksville	280
Hamilton	380
Brantford	100
St. Catherine's	130
Niagara Falls	20
Kingston	80
Bellevile	80
Brockville	50
Kitchener	230
Guelph	100
Galt	90
Stratford	40
London	310
Woodstock	40
Sarnia	80
Windsor	230
Chatham	50
St. Thomas	60
Leamington	20
Sudbury	240
North Bay	230
Sault Ste. Marie	100
Brampton	150
Owen Sound	60
Barrie	80
Oshawa	60
Weston	400
Scarboro	400
Oakville	60
Kenora	40
Dryden	40
Fort Frances	20
Thunder Bay	310
Atikokan	20

(Cont'd)

TABLE 1

Province & City	Qty.
MANITOBA	
Winnipeg	1400
Brandon	100
Dauphin	50
The Pas	100
Gillam	20
Churchill	50
Thompson	70
Flin Flon	50
SASKATCHEWAN	
Regina	440
Saskatoon	440
North Battleford	60
Prince Albert	100
Yorkton	50
Estevan	50
Weyburn	50
Moose Jaw	80
Swift Current	90
ALBERTA	
Calgary	1300
Red Deer	60
Medicine Hat	100
Lethbridge	160
Drumheller	20
Edmonton	1400
Lloydminster	20
Jasper	50
High Level	20
Grande Prairie	100
BRITISH COLUMBIA	
Vancouver	2600
Chilliwack	40
Abbotsford	40
New Westminster	150
Powell River	20
Langley Bank	40

Province & City	Qty.
BRITISH COLUMBIA (Cont'd)	
Kamloops	230
Revelstoke	50
Vernon	110
Kelowna	110
Penticton	110
Nelson	100
Cranbrook	120
Trail	60
Nanaimo	100
Campbell River	50
Courtenay	50
Port Alberni	50
Victoria	270
Duncan	40
Prince George	360
Smithers	50
Terrace	70
Prince Rupert	80
Burns Lake	20
Kitimat	50
Quesnel	40
Williams Lake	40
Dawson Creek	100
Fort St. John	100
Fort Nelson	40
NORTHWEST TERRITORIES	
Hay River	100
Yellowknife	50
Inuvik	50
YUKON TERRITORY	
Whitehorse	150
Watson Lake	50
TOTAL	29230

Coverage - Subscriber Lines

DATA TELEX NETWORK

Province & City	Qty.	Province & City	Qty.
NEWFOUNDLAND		MANITOBA	
St. John's	20	Winnipeg	100
NOVA SCOTIA		SASKATCHEWAN	
Halifax	50	Saskatoon	40
		Regina	40
NEW BRUNSWICK		ALBERTA	
Moncton	60	Edmonton	60
		Calgary	100
QUEBEC		Grande Prairie	20
Montreal	160	BRITISH COLUMBIA	
Quebec	40	Vancouver	150
Senneterre	20	Nelson	20
ONTARIO		Kamloops	20
Toronto	200	Nanaimo	40
Kingston	20	Prince George	20
Hamilton	40	Victoria	40
London	40		
Kitchener	40		
Sudbury	20		
Thunder Bay	20		
Ottawa	40		
		TOTAL	1420

TABLE 2

2.7 TWX - Economics of the Present System

2.7.1 Introduction - The following is extracted from a TCTS letter of July 7, 1970.

2.7.2 Equipment Inventory - Year End 1969

- TWX machines - 3840 (including on shelf backup equipment).
- Each machine has an associated data set.
- There are 14 positions of the 6A Dial Assistance Board located in Montreal.
- Inventories on facilities, switching, etc. are not specifically accounted on a basis which permits identification to individual service offerings. These facilities are normally shared with many other service offerings of the Telephone Companies.

2.7.3 Planned Plant Expansion

- Growth in terminal equipment is anticipated to be in the 10% range for the next two years.
- TWX usage and its growth trends are incorporated in total usage and growth forecasts and cannot be identified without conducting extensive and detailed studies.

2.7.4 Capital Investment

The existing investment which can be clearly identifiable to providing TWX service is approximately $17.0 million. This figure includes machines, data sets, junctors, trunk relay equipment, dial assistance boards, speed and code converters and test equipment. No attempt has been made to allocate facilities used on a shared basis with other Telephone Company services such as circuits or switching facilities.

It should be noted that nearly 700 TWX stations are used by the Trans Canada Telephone Companies in conducting their own business and for intra-industry intercommunications. Thus a significant portion of investment is dedicated in furnishing communications to the industry for which no revenue is allocated in these statistics.

Capital investment forecasts are generally restricted to machine and data set requirements which are anticipated at 10% for 1970-71.

Revenues - Total TWX revenues within Trans-Canada were $4.3 million for the year 1969. Forecasts indicate a year on year increase of 10% per year for the 1970-71 forecast period.

2.7.5 General - Operating costs associated with TWX are not accounted independently and as such are unavailable. Most Telephone Company people (sales, business office, engineering, maintenance, installation, etc.) are multifunctional and they, as well as the costs incurred in supporting them, constitute a minor expense in the cost of the total business. Special and lengthy studies would have to be undertaken to approximate specific costs in this area.

2.8 Government Usage of Telex

The Government is a very large user of teletype services. Annual expenditures for teletype and telegram messages approximate $1.7M (Million) of which $1.1M is for Toll charges. The system serves all provinces and a total of 254 localities. Complete details of the service are available in the Government Telecommunications Agency. A statistical study of usage by twenty-seven Federal Government Departments and Agencies was conducted in April 1968 by that agency and informative extracts from this study are reproduced herein.

2.8.1 Considerations - The Government employs no TWX service. Reasons advanced for this situation are as follows. Historically the Telex service started first and when TWX came along it offered no advantages conducive to a changeover. Secondly the Telex service is more economical for the purposes of the Government. This is because the Government also makes use of extensive telegraphic services. These are combined with Telex in the Tel-Tex system to provide essentially a cheaper telegraphic service. In addition, of the 15% approx of Telex messages which go outside the Government system, the Tel-Tex system has a 4 to 1 chance of reaching a receiver more cheaply than TWX because of the greater number of Telex terminals.

The extent and distribution of the government services are given by Table 3. Typically there are 3 to 4 terminals per community. The 1968 report notes a total of 111,853 messages in the one month period with an average message length of thirty words. Table 4 gives distribution of the service by Departments and Agencies.

The Government is by all standards a very big user of teletype service, and it has selected Telex as the Message-Record service most suited to its needs.

Government of Canada Telex Services

As of March 31, 1970, 725 Telex machines were in service for 44 Departments and agencies in 254 communities in Canada.

Distribution by Provinces:

	Units	Communities
British Columbia	119	46
Alberta	57	20
Saskatchewan	46	18
Manitoba	54	18
Ontario	193	45
Quebec	127	61
New Brunswick	22	11
Prince Edward Island	4	2
Nova Scotia	46	13
Newfoundland	23	10
Yukon	9	3
Northwest Territories	25	7
	725	254

TABLE 3

Telex Distribution by Departments/Agencies

	Units
Manpower & Immigration	193
Transport	110
R.C.M.P.	95
U.I.C.	59
Indian Affairs & Northern Development	40
National Defence	25
Post Office	18
Public Works	18
Agriculture	16
External Affairs	13
Industry Trade & Commerce	12
Supply & Services	12
National Harbours Board	11
Solicitor General	10
Government of Northwest Territories	9
National Research Council	8
Northern Canada Power Commission	8
Energy Mines & Resources	8
Regional Economic Expansion	8
St. Lawrence Seaway Authority	7
Fisheries & Forestry	6
National Health & Welfare	5
National Revenue	4
National Film Board	3
Secretary of State	3
National Library	2
Canadian International Development Agency	2
Dominion Bureau of Statistics	2
Labour	2
Canadian Transport Commission	2
Veterans Affairs	1
Public Service Commission	1
Defence Construction Limited	1
Crown Assets Disposal Corp.	1
Communications	1
Canada Council	1
National Parole Board	1
Privy Council Office	1
Export Credits Insurance Corp.	1
Finance	1
Governor General	1
Canadian Livestock Feed Board	1
Canadian Radio - Television Commission	1
Defence Research Board	1
	725

TABLE 4

PART III INTERCONNECTING TELEX WITH TWX

3.1 Introduction

The foregoing has provided a brief description of the operation and technical characteristics of the Canadian TWX and Telex networks. The following will attempt to outline in general the problem areas in interconnecting the two systems.

3.2 Comment from CN/CP Tel

To appreciate fully the differences in the two systems, it is necessary to first describe briefly the basic concept of the TWX system. Each subscriber is connected to an automatic telephone central office and is able to dial and establish connections over the DDD network. Adaption of the teletype or other digital equipment to the long distance network for transmission over a voice communication network in the frequency range of 300 to 3000 cps is accomplished by the use of the Data Set at the subscriber's location. Since calls are to be initiated and established over d-c controlled, local subscriber loops, the subset provided has a standard dial and a "receive only" handset, as well as a ringer and pushbutton for controlling the Data Set. The central-office switching equipment establishes connections and provides audible supervisory tones in the same way as when handling telephone traffic.

A typical Data Set utilizes the frequency modulation mode and provides two frequency-divided transmission channels to allow transmission in both directions (1170 ± 100 cps, 2125 ± 100 cps). The two extreme frequencies in each channel are assigned to the two digital states (mark and space). On receipt of the dc pulses (binary, serially coded bits) the tone frequencies shift 200 cps between 1270 and 1070 in one channel, and between 2225 and 2025 cps in the other channel. The above tones are also used for supervisory function (i.e. answer supervision, circuit assurance), and the frequency 2225 cps is used for disabling the echo suppressor on the telephone network prior to data transmission. The 200 cps frequency shift provides a theoretical maximum information rate of 200 baud. The Data Set is also equipped with data interface leads to the teletype or other digital equipment for control purposes.

In both Telex and TWX systems the subscriber is able to dial other subscribers in his respective network. The significant difference between the two systems is the method by which the transmission path is established. In the TWX system, DDD telephone is used, making it necessary for the signals to be in an A.C. analog form. In Telex, the exchange equipment, although similar in principle so far as the switching function is concerned, is designed and equipped to handle the signals from the subscriber in the original digital form (serially coded DC pulses); therefore conversion to analogue form is required only for long distance transmission over the inter-exchange trunks. Voice frequency carrier telegraph is used to effect this conversion.

Because different modes of operation are involved, the information and supervisory signals from the subscriber to the exchange equipment must be unique to the type of system he is connected to. As a result the subset and associated control equipment are entirely different in the Telex and TWX network; the only similarity is the common use of d.c. dial pulses for transmitting the digits of the called number.

At each subscriber location in the TWX network at least one Bell system provided teletypewriter is required depending on the requirement of the customer. The teletypewriter may be either a Model 33 or 35 (8-level). Although the machines provided on each network are basically similar, the control and leg circuitry are quite different and are therefore, not compatible.

An essential element in both Telex and TWX networks is a numbering system wherein each digit dialed has a significant meaning. The numbering plan for the Telex network has been briefly discussed. It is quite obvious from our knowledge of the numbering plan for direct distance dialling on the telephone network that there is little similarity between the two numbering plans.

Before any consideration is given to interconnecting these two systems, these basic differences must be recognized. Other factors such as accounting, traffic flow, etc. must also be considered and systematic studies be carried out to determine the nature of the problem and applicable approaches to resolve these differences. While it is not within the scope of this presentation to discuss the method by which this interconnection can be made possible, it is apparent from the magnitude of the task that the computer must be an essential element in the transfer, control and processing of information between the two networks.

3.3 Comments from TCTS

3.3.1 Introduction - The following is taken from a TCTS letter dated July 7, 1970.

3.3.2 Technical Comparison of TWX and Telex - At present both systems use electromechanical terminals, however, the codes being transmitted by these terminals vary considerably. Telex uses the 5-level Murray code which is compact and well suited to "telegram" type message traffic. This code makes efficient use of bandwidth, however, it is awkward for use on Data I/O devices due to slow speed and a limited character set. TWX uses the 8-level ASCII code which is less efficient (longer) but it allows for 4 times the number of unique characters which offers some advantage in the provision of data services.

Development trends in machines are toward non-impact printing terminals and CRT type devices. These could be adapted to TWX with little effort. However, due to code limitations, these developments are not likely to be compatible with Telex service. TWX uses basic telephone switching technology which is constantly being improved, whereas Telex uses DC switching technology which is relatively inflexible.

The following is a summary of the main characteristics of each service:

Characteristic	TWX	Telex
Dialing	Dial pulse or Touch Tone	Dial pulse
Supervision	DC Loop	DC Loop

Characteristic	TWX	Telex
Local Loop Transmission	Full duplex frequency shift keyed tone on voice channel	Half duplex D.C. pulsing on telegraph channel
Trunk Transmission	Full duplex frequency shift keyed tone on voice channel	Voice frequency Carrier Telegraph on voice channel (Max. 20 ccts./voice channel)
Coding	8-level ASCII (CCITT 5)	5-level Murray
Usable characters	128	32 (59 with shift)
Parity	Yes	No
Data rate words/min.	100	66-2/3
Signalling rate baud	110	50
Switching	Regular voice network	"Dedicated" network
Numbering Plan	10 digit	6 digit
Billing	Detailed	Bulk

Two types of Telex dialling are used, viz Type A and Type B. Type A (Overseas via COTC) signals by means of the teleprinter keyboard. Type B (CN, CP & Western Union) signals by means of a standard telephone dial.

Consideration of the above comparative chart provides evidence of the difficulties of interconnecting the two Communication Networks. True interconnection of TWX and Telex could only be achieved by providing interface equipment at suitable gateways between the two systems for code, speed, transmission mode and numbering plan conversion.

The alternatives of converting all TWX station, transmission and switching equipment to corresponding Telex equipment or of converting all Telex equipment to TWX equipment would require the abandonment of significant capital investment in the system to be converted and new capital expenditures would be needed for replacement.

In the absence of any significant demand for the interconnection of TWX and Telex services the cost of the alternatives outlined above may not be justified. The typical $45 per month charge for a machine to access the second service may well be the most practical way of providing for the small number of customers who require this flexibility.

3.3.3 Summary - In summary it appears that there are two markets to be served. Telex is designed primarily for message communication - the conveyance of generally unstructured narrative information for personal action, or record - for which it is extremely efficient. TWX lends itself better to the conveyance of precise and highly structured information in compatible record form which is well suited to modern data communications needs.

3.4 Extract from FCC Docket

The following is a summary of technical incompatibilities between TWX and Telex extracted from an FCC docket.*

1. TWX is an analogue system using voice frequency tones to enable the signals to pass through the voice system. There is a supervisory DC signal associated with TWX, as with telephony.

* (Pages 4, 5, 6, 7 of W.U. Exhibit 3, F.C.C. Docket No. 18519)

2. Telex is a digital DC system. Its signals will not pass through a telephone system end to end.
3. TWX teleprinters require a modem (equal in cost to the teleprinter) to convert printer outputs to the analogue tone forms, and conversely.
4. Telex teleprinters do not require a modem.
5. The high quality telephone switches used for switching TWX traffic share common controls with telephone traffic and will not pass Telex subscriber signals through the exchange.
6. The present family of Telex switches uses modifications of telephone switches and these switches will not pass TWX tones.
7. The TWX subscriber can hear call progress tones such as dial tone and busy tone. These tones will not pass through Telex switches.
8. The progress of calls in Telex is indicated by digital signalling at the terminals.
9. Telex multiplexes up to 20 channels in a single voice band, using an effective bandwidth of about 150 Hz.
10. TWX generally uses a full voice bandwidth (3-3300 Hz) per subscriber call.

3.5 C.O.T.C. Input

This organization has for some years maintained facilities at its overseas terminals with which to effect two way code conversions Telex - TWX. Traffic from overseas originates from Telex terminals. The need for conversion to TWX at Montreal or Vancouver has not developed on the scale that was anticipated. Plans are now far advanced to effect the conversions by entirely different means.

A computer is being installed at Montreal to control Telex switching and to produce billings automatically. This computer will be in service in 1970. An additional software program will be written to effect the code conversions. Thus COTC will always be in a position to respond to TWX or Telex inputs, and interconnection of the two systems would require minor software changes only. COTC experience in this field however would be valuable if any other centers for code conversion in Canada were to be set up. For example in the COTC letter of 21 May, Mr. J. Crispin, Chief Engineer, points out that conversion centers require operator assistance to the subscribers.

PART IV STUDY OF DEVELOPMENTS IN THE U.S.

4.1 Western Union Acquisition of TWX from A.T.&T.

4.1.1 Background - In 1953 a U.S. Senate sub-committee recommended the acquisition of the A.T.&T. TWX system by Western Union (W.U.) and the latter company made an offer to buy the TWX, teletypewriter and telegraph services from A.T.&T. The offer was rejected.

In May 1962, alarmed by certain developments in the intervening years, the F.C.C. initiated an investigation into the conduct of the domestic telegraph industry. The volume of public messages via telegraph had dropped 60%. The loss of this business had placed Western Union in a weakened position to serve as the competition to the telephone giant. There was a desire to find out what responsibility W.U. had for this serious situation.

The resulting inquiry culminated in an important report, F.C.C. Docket No. 14650, April, 1966. This report made recommendations leading to the current acquisition proceedings and it also offered a review of the principles that should guide the development of all forms of record message services in the U.S. except those associated with computer oriented data. The study was completed before computer services had developed to the point which commands attention.

4.1.2 Summary of Reasons Advanced as Cause for Acquisition - The committee expressed concern over the reduction in the facilities being offered for public telegraph messages. This was considered to discriminate against the 'residual user' who could not afford any other service.

It was concluded that means had to be found to sustain this service.

Long term U.S. policy has been in support of the benefits inherent in competition except in a limited field of service which is so affected by public interest as to justify extensive regulation. In fact in the U.S., as in Canada, voice communication was, and is, still the only means of communication firmly recognized to be a natural monopoly. The committee was of the opinion that forcing action had to be taken to maintain even a semblance of competition in the industry in the U.S.

It was considered that the best way to support competition was to ensure to Western Union a large enough segment of the communications market for the company to remain viable. This was foreseen also by the Senate Sub-committee in 1953 which stated, quote "the acquisition of the teletypewriter services (TWX, there was no Telex then) would strengthen and stabilize the financial structure and competitive position of the telegraph system" (operated by W.U.).

Finally the committee foresaw technical advantages and economies resulting from planning for an integrated message-record system.

4.1.3 Protective Conditions - The recommendations were qualified by a number of conditions that had to be established to protect the public interest and the new positions of W.U. and of A.T.&T. These are of interest in considering developments in Canada.

Provision was to be made for the following:

Promotional pricing	Western Union to be required to set up "promotional pricing" schemes designed to test the user interest between the various record systems and hopefully to encourage interest in the public message service which is most accessible to the residual user.
Tariff structure	That Western Union revise its tariff structure to maximize the usage of each type of service according to its value and cost of service characteristics.
No re-entry	Means for preventing A.T.&T. from re-entering the TWX market (but specifically permitting A.T.&T. to combine Data-phone and teletype facilities).
Leasing	F.C.C. to regulate terms for leasing by one carrier to another.
Interconnection	Elimination of interconnection restrictions between A.T.&T. and Western Union on private line services.
Rates	Bell and Western Union each be required to fix rates that yield a fair rate of return on those services that are directly competitive subject to the condition that the carrier with a lower rate and a fair rate of return will control the rate, and will be the rate "bellwether".

4.1.4 FCC Develop Need For Balance in Size Between W.U. and A.T.&T. -

Pricing — The Commission concluded that pricing by Bell for those services directly in competition with W.U. resulted in earnings levels which appeared to be deficient. Thus Bell was relying upon the relative unimportance in its overall earnings record, of the message-record, compared to voice traffic revenues.

Size — The Commission expressed the opinion that "the greatest problem facing Western Union, in such a duopoly setting, is the impediment to its capacity to diversify into areas that involve more and more direct competition with the telephone company. A.T.&T. size constitutes a clear barrier to entry."

Prior Customer Contacts - Bell's pre-eminence in the field of exchange and toll telephone service provides them with prior customer contact. A very pervasive penetration is enjoyed by the telephone company in this respect because additionally the public tends to consider Bell as synonomous to communications services.

Innovation — The financial resources, and the vertical integration of facilities from research lab to production, gives the telephone company a tremendous advantage as an innovator.

Sales — Owing to the imbalance in revenues the telephone company has a great advantage in funds available for sales promotion. The Commission found that the A.T.&T. sales budget was more than 17 times greater than that of W.U. and that it penetrated both social and business fields. It was considered that the Bell expenditures were sufficient to saturate the market.

Bell has the ability to provide a full line of communications services to meet the growing demand for more versatile communications services.

Access to Financing - The Commission found that there was a vast system of interlocking directorates tying A.T.&T. to the major manufacturing, banking, and insurance interests in the nation. This situation made it easier for A.T.&T. to go 'on the market' for financing.

4.1.5 Supporting Services Afforded By Bell - The Bell system has adopted certain procedures for the delivery of telegrams by telephone and for billing for telegrams telephoned from the customer's premises. For these services Bell receives payment from W.U. The arrangement apparently has been satisfactory to both parties.

The Bell system holds many patents and these have been made available to W.U. without restraint.

The Bell systems owns Teletype Corp., the principle source of teletypewriters in the U.S. No restriction on sales to W.U. has been observed.

4.1.6 Pertinent Opinions of Other U.S. Interests Expressed at FCC Hearings - Hearings were held by the FCC to obtain the views of a significant number of organizations as listed in Appendix A, which formed a cross section of opinion of public and private interests. Brief comments on these submissions follow. Similar views undoubtedly could be obtained in Canada on some of the issues under discussion. Views of the principals are also summarized.

Western Union

1. Would prefer an Umbrella pricing scheme permitting the use of averaging techniques covering several services.
2. Request elimination of what is called 'single source pricing', i.e., cancellation of TELPAK, WATS and other such tariff schemes originated by BELL.
3. * Request freedom for certain interconnections between Bell and Western Union which would be "in the public interest".
4. Would expect an FCC decision to ultimately split the industry between voice and record.

Bell

Generally willing to cooperate with FCC wishes, but would prefer the status quo.

Aeronautical Radio Inc.

Against a voice-record split in the industry.

* Notably interconnection of W.U. private lines through Bell exchanges ending at a subscriber not using Bell terminal equipment.

Communications Committee

Against 'Umbrella' pricing

Allow Western Union to cut any unprofitable service

I.T. & T.

Effect voice-record separation

Defense Agencies

1. Opposed voice-record split
2. More interconnection for maximum flexibility
3. Require maximum diversity
4. No subsidy, direct or indirect to W.U.

General Services Administration

1. Cost of service to be basis of rate-making no umbrella pricing
2. No subsidy
3. Free interconnection

American Communities Association

1. Enhance competition between Bell & W.U. by making more equal in size, using voice-record split
2. Split Bell up into functional organizations
3. Against 'Umbrella' pricing
4. Require better performance of W.U.

Commercial Telegraphics Union

Separate voice-record facilities. Transfer TWX to W.U.

4.1.7 Interview with Western Union, February 24, 1970 - On the above date an interview was conducted with Mr. G. Strunz, Assistant Vice President Business Relations, Mr. Cox, Assistant Vice President Communications Systems and Equipment Design, as well as marketing and business officers. This was an informal discussion concerning policy and technical matters. Points of special interest are discussed briefly in the following paragraphs.

Western Union are firmly of the opinion that their organization is not big enough to engage in open competition with the telephone companies and that consequently survival depends upon protection secured by government regulation. The company generally does not wish to provide any services jointly with the telephone companies, recognizing, however, that in some cases, e.g. private wire systems, interconnection is necessary.

According to W.U., competition after the acquisition will be insignificant in the field of TWX and Telex services. There will be continuing competition for private line services, and from other Bell services such as the combination of Data-phone and teletypewriter, although no more teletypewriters, TWX and Telex services will be provided by Bell system companies after the effective transfer date.

It was noted that the present population levels for the two services are:

Telex	32,000 subscribers
TWX	43,000 subscribers

Basic requirements for connection of TWX service has been reached between TCTS and W.U., for a ten year term. TCTS has the option of utilizing W.U. Telex Computer Communications Services (TCCS) for interconnection to Telex systems in the U.S. Code conversion and multiple addressing will be part of the service. Discussions are under way with CN/CP concerning opposite interconnections.

When asked which system W.U. proposed to sustain over the long run the answer was that a changeover to digital technology is foreseen. Reasons given were longer life of terminals, denser circuit packing and particularly savings in modems.

W.U. are committed to take the TWX system out of the A.T.&T. toll system wherever possible. One of their first steps will be to replace Bell microwave trunks with their own.

The F.C.C. have directed W.U. to set up a trial network which will give real time speed and code conversion between the TWX and Telex systems. Delays through a TCTS center vary between seconds to as much as 1/2 hour depending upon the traffic. W.U. believe there is no serious customer objection to such delays.

W.U. permits Telex subscribers to supply their own terminals but only after the first unit.

Considerable discussion took place on the growth and nature of data-oriented services. First a definition of Data processing as distinct from message transmission was advanced by W.U.

to be

> "If the output message reveals the form of the input, i.e. it is possible to reconstruct the input message, then a message service and not Data processing is being provided, and conversely."

4.2 Integration of TWX-Telex in the U.S.

4.2.1 Subscriber Terminals - Subscriber terminals for both services are supplied mainly by Teletype Corp. of America which is owned by A.T.&T. However W.U. state that it is satisfied with service and prices offered by the Teletype Corp. W.U. would be willing to consider any other supplier which is prepared to make a competitive price/performance bid. Integration will not result in a common new terminal suited to both TWX and Telex. Units now offered by the Teletype Corp. have already been designed to this end as far as is practicable. Very many models are involved, as TWX and Telex both offer a variety of features which can be tailored to the subscriber's order.

In the Thomas F. McMain exhibit reference customer provided terminals, it is stated that a split will be made between TWX "Prime" service and public exchange service. In the "Prime" service signalling frequencies are inverted and only "Prime" Bell system subscribers can communicate. These subscribers may provide their own terminals and operate the system as a private network but modems must be supplied by W.U. until acquisition.

When acquisition is completed W.U. will permit customer provided modems which must be isolated from the network by W.U. isolators which will generate necessary control signals.

After acquisition, W.U. will develop facilities to allow subscribers to attach their own terminal equipment to W.U. public exchange networks. The technology is not complete as yet. Problems include code and speed compatibility, answerback compatibility, other electro-mechanical compatibilities and adequate maintenance (of customer terminals). W.U. also stipulate that use of customer provided modems will be subject to the following:

1) Only approved types of terminals will be permitted. (This would require an independent approval agency to be set up).

2) Network control and interfaces will be supplied by the carrier.

4.2.2 Systems - Consideration of referenced documents and discussions with W.U. officials confirm that all interconnection planning is based upon the use of central computer processors, a build-up of Data services, and conversion to digital transmission techniques. The long range objective is for a totally integrated, data oriented, low and high speed message record system. Many of the details of the plan will have to be worked out only as the changing economics of new switches and of digital transmission become more evident.

The multiplicity of services being offered as between public message, teletype message, various forms of Data, when compounded with the need to provide international services links (Overseas, Canada, Mexico) typically results in a matrix of many possible forms of interconnection which have to be supplied on a national scale. This makes for complex computer processor programs as well as complicated distribution networks.

Among the functions to be provided by the computers, will be store and forward, multiple address, code conversion, repeat calls and many others.

After the acquisition of TWX, W.U. intends to supply Telex Computer Communications Services (TCCS) to a certain class of TWX subscribers. This will permit message relay services for TWX to TWX, TWX to Telex, and TWX to telegram. TCCS will be a computer aided facility.

Planning for the changeover in the U.S. will provide for the continuation of several types of service some of which do not exist in Canada. W.U. intends to remove the TWX from the telephone company's switching plant. The fact that W.U.'s switching plant is loaded now in many areas means that integration can only proceed as fast as new common plant switching equipment can be secured and installed. There would not be an exact parallel in Canada under similar merger circumstances since the ratio of Telex to TWX in Canada is about 4:1 whereas in the U.S. it is closer to 1:1 and therefore the present TWX cannot be simply scrapped or diverted to other services in the U.S.

Only a detailed after-the-fact study of the technical methods adopted in the U.S. would be of benefit reference any integration proposal for Canada. There is therefore no purpose to be served in recording more than the general points that have been discussed.

For an interim period at least, W.U. expect to service Data over their standard Telex facility. The standard speed will be upped to 100 w.p.m. from 66 w.p.m. and the ASC11 code will be employed. All short haul and trunk routes will eventually rely upon digital techniques only, for high speed transmission of Data.

4.3 Future of the Technology According to Western Union*

Western Union are of the opinion that provision for future services will make mandatory system designs which will include high speed digital transmission techniques, common signalling channels, and time division circuit technologies in the switching equipment. Very rapid call set up times will be made available. It

* Reference F.C.C. Docket 18519, pages 9, 10, 26

will be possible to engineer the system on a delayed call basis rather than a lost call basis.

Western Union believe that "Communications switching centers should be essentially transparent to codes and speeds and be insensitive to traffic constraints such as call holding times. That is, if an expandable data-record communication system is to be achieved, the switching center must not be designed on the basis of telephone voice switching center requirements, nor can it be a development produced by a simple modification of the present type of voice switching system (as are the present Telex and TWX switching centers). The communication switching centers must be designed on different principles. They must be oriented toward the special requirements of the data world".

Western Union now have a 7900 mi. nationwide Electronic Data Communication (EDC) network. In a recent filing with the F.C.C. for permission to extend a microwave system 400 mi. from Cincinnati, Ohio to Atlanta, Georgia, it was noted that the system would provide 216 voice frequency analogue channels and 165 digital data channels.

4.4 Interview With Senior A.T.&T. Staff

In a meeting with V.N. Vaughn and P. Muench at A.T.&T. Headquarters, April 21, 1970, the following observations were made.

The telephone companies regard the TWX acquisition ruling as giving Western Union five years to get established in message-record and low speed data without competition from Bell. During this 5-year period except for not offering switched Teletypewriter service at less than 300 bps, Bell will be actively adapting their services to suit all other needs of data customers. They already provide 50 kbps private line service via group band 48 kHz facilities as well as a limited (4 cities) switched 50 kbps service. Plans are being made to expand the switched 50 kbps service to cover more Metropolitan areas. The use of selective routing and the newest crossbar switches in this service allows connect times (end-of-dial to start-of-ring) averaging about 3 seconds on an interoffice call.

They have formed a new data group at Headquarters specifically to put more intensive effort on medium range (5-10 years) planning of new data services. The proposed new service includes a private line digital data service based on present and planned digital transmission systems to be used in the telecommunications network. The group is also studying a variety of switched services including some in which the charge would be based on the amount of the information transmitted, e.g., the number of characters, rather than the length of time the connection was held up. Mr. Vaughan expressed the view that standard 50 baud Telex will never qualify as an important data medium. He had heard of intensive studies in Europe to determine how to integrate Telex with Data in new networks. Discussion on a suitable definition for "Data" was inconclusive. A.T.&T. vouchsafed that about 50% of "information" transferred today - allowing for the excessive redundancy in speech, is done via Data services. However only about 5% of the telephone plant is occupied at any time by Data. With the introduction of picturephone and other video services it is unlikely that Data will ever absorb more than 5-10% of the telephone plant.

4.5 Relation of U.S. to Canadian Situation

4.5.1 Background U.S. Policy - The U.S. Government, through cabinet directives and its agent the F.C.C., have recently taken a number of significant steps to liberalize the regulations concerning telecommunications. The effect has definitely been to widen the doors to competition and to reduce the telephone company monopoly. An early break was the Carterfone case resulting in removal of restrictions on the use of customer supplied terminal equipment. Recently MCI, a new potential carrier, has been granted a licence to install and operate microwave systems spanning one-half of the continent. Currently also an application is being considered from a new company, DATRAN, which wants to build a microwave system to transmit "Data" only. And the F.C.C. is effectively building up Bell's principal competition through forced merger of the TWX-Telex. Note, however, this is not intended to be the beginning of a complete voice-record split between Bell and W.U. in a duo-monopoly situation, otherwise, the DATRAN filing would not be considered at all.

4.5.2 Corporate Relationships - Western Union has had a natural cross-over with CN/CP Tel since both sell Telex services. The relationship has been a pragmatic one. It has been shown that Bell Canada will obtain similar support from Western Union and certainly it has already been established that W.U. wish to make provision in their integrated system for Canadian-U.S. traffic. As a result of these relationships Canadian carriers will enjoy equal opportunities for interconnection with the two U.S. systems.

4.5.3 Economics - The arguments advanced by the FCC on the score of monopoly economics may be as cogent in Canada as in the U.S. The disparities in capabilities for sales promotion, pricing practices, and particularly for innovation, are evident in Canada. The fact is, that a small monopoly operating in the shadow of a much bigger monopoly is constantly under pressure and generally is in an unstable position, unless firm government regulations give it extraordinary support.

4.5.4 Finance - There are major differences between the U.S. and Canadian situation in the financial realm. Bell Canada has been pushing an expanding bow-wave of debt ahead of it for years. Currently it is having difficulties in obtaining new financing which are related to world financial conditions and to its profit record. The CN/CP is a working alliance and does not resemble W.U. One half of the alliance is a crown company, the other half, the CPR, is a giant conglomerate. The ability of CN/CP to raise funds has probably never been fully tested. One may ask however, how far can the Government go with direct financial aid to support competition to the telephone monopoly? It is possible that the Bell Canada system does not have the financial advantage that A.T.&T. have had in the U.S.

4.5.5 Considerations - It is clear that the U.S. government has concluded that there was too great an imbalance between the major communications carriers. As we have seen, the FCC has moved effectively to guarantee an accelerated growth for W.U. through expansion of the TWX-Telex services which have a great future. Concurrently the FCC has moved to block the growth of the Bell system by opening up the continental microwave routes, and particularly so, since these are to be used for Data transmission. This tends to limit Bell growth to voice/videophone and its derivatives, whereas many experts envisage the value of Data traffic to eventually surpass these. It would be unwise to assume that A.T.&T. can be counted out of Data transmission services, on the contrary A.T.&T. are organizing a long range program to start with services like DATAPHONE and eventually to win a major share of the market.

In Canada, the Government has already given support to the concept of inter-carrier competition through direct or tacit support of the CN/CP Telecommunications alliance. The degree of competition however has limiting factors similar to those which were observed in the U.S. by the F.C.C.

The development of the new integrated services in the U.S. is to be keyed-in to computers as we have seen. Very considerable sums will be invested in computer programs for system control. Since there is to be a cross-over between U.S. and Canadian systems the technical inter-relationships could be simplified if the Canadian service was unified. It would be advantageous also if W.U. knew the Canadian plans now for development of the services on a long term basis, because as their own system develops, their computer programmes are going to get more and more complex, and costly to change. In fact if different computers were used on either side of the border it would further complicate the programming problems to the point where it could be economically impractical for W.U. to serve Canadian requirements completely.

4.5.6 Conclusions - (1) The U.S. Government has legislated for the institution of a single Record-Message system.

(2) This system will be extended in function by W.U. to include Data transmission.

(3) The telephone companies will remain in the field via medium and hi-speed switched data service.

(4) Whereas the W.U. system effects a voice-data split, those media will be developed in a parallel series sequence in the next two decades.

(5) Integration of TWX-Telex and other Record-Message, Data services in the U.S. is being planned on a Continental basis. This is being done without benefit of an expression of a Canadian government position on related long term policies regarding similar systems in Canada.

PART V TCTS POSITION PAPER ON TWX-TELEX INTERCONNECTION

The entire text in this part is a verbatim extract from the TCTS paper prepared for this study.

Quote: "TWX and Telex were initially developed as teletype message services. Since CN/CP entered the market place well in advance of the TCTS Companies, they had a large user group already in existence at the time TWX was introduced. To this day Telex is the most widely used vehicle in Canada for switched teletype message service.

Although TWX is quite capable of providing teletype message service, it has also evolved, because of its technical features, as an excellent vehicle for supplying data services. While Telex has grown to acquire significant gains in the "random message" business, TWX has evolved into a number of in-house customer systems. Recent studies indicate that approximately 80% of the TWX terminals, are used primarily for in-house low-speed data carrying purposes rather than for random message capability.

The TCTS Companies feel that this factor is of prime importance to the subject of TWX-Telex interconnection. The 8-level code and 100 words per minute speed features of TWX have strongly established TWX as a basic introductory service for users of data services. Having this offering has allowed the telephone carriers to provide their data customers with basic service initially and grow with them as their more sophisticated needs evolve. Of considerable importance in this area is the fact that once a data user is committed to a specific data format within his business, he becomes economically committed to systems design, computer language, speed of operation, business forms, etc., making it extremely expensive and wasteful in resource allocation to change.

The late arrival of TWX into the market place permitted the inclusion of several features in its system design which have proven most attractive from a data use standpoint. Although there is some overlap, two different and distinct markets for TWX and Telex now exist. A recent study gives some statistical evidence of this fact in that only 1.5% of all TWX and Telex users have acquired machines to access both networks. This factor cannot be considered conclusive because of other differences in rates, message length, cross border concerns, etc. However, for the price of $45.00/month, a user of one service can acquire a terminal on the other network. To date less than 2% of all users have done so.

In evaluating interconnection of the two networks, there appear to be a number of alternatives to consider.

- Establish a point of interconnection while maintaining two prime suppliers.
- Amalgamate the two services under one carrier.
- Retain the current status.

Regarding these alternatives the following comments should be considered: -

- Carriers in the data business need an entry offering to the low speed data market. To exclude one carrier from this field would give an unfair competitive advantage to the other. Data users become economically committed to a particular system and are naturally reluctant to change once committed.

- The costs associated with making the two networks technically compatible will be high. Interconnection costs are directly related to speed and code conversion. Interconnection can only be effected at locations equipped to receive traffic in the 8-level ASC11 code at 100 words per minute on voice grade facilities and retransit it in the 5-level Murray code at 66 2/3 words per minute on telegraph grade facilities and vice versa.

  This type of problem is serious enough in the case of international traffic which flows through a relatively small number of recognized border-crossing points or "gateways" which provide natural locations for the conversion. In the case of domestic traffic between carriers who serve the same territory, the converter locations would have to be numerous or a large proportion of the traffic would have to be carried twice, i.e. back-hauled, over the same route.

  In Canada with its population distributed in a strip approximately 4,000 miles long and 2000 miles wide, the "back-haul" could span great distances (e.g. a TWX to Telex call with both stations in Vancouver routed via a converter located in Toronto).

- Should the cost of interconnection be paid by those who use both networks or by spreading the costs across the general body of users? Since there is little evidence that a high degree of demand for interconnection exists at the present time, a general rate increase to pay for the cost of interconnection would not appear to be in the best interest of the general user.

- Interconnection would introduce billing and division of revenue problems because of variances in the rating structures of the two services. Different timing allowances, calling areas, speed of transmission, etc. contribute to this problem.
- Single ownership of the two networks would not solve the foregoing problems.
- A decision to retain one service only, would require the abandonment of the investment in station equipment and central office switching gear for the discontinued service. Furthermore, an additional investment would be incurred to replace those services provided by the discontinued offering.
- Retaining the current status -
    - . provides for the maintenance of a degree of competition which had stimulated market development and increased user choice and option.
    - . permits each carrier to market a full range of data services.
    - . avoids the high cost of accommodating technical interfacing and conversion related to interconnection.

In conclusion it is the recommendation of the TCTS Companies that the TWX and Telex offerings of the two carriers should not be interconnected or combined.

PART VI WHAT WILL HAPPEN IF THE GOVERNMENT DOES NOT INTERVENE

6.1 Future Development of Telex & TWX

We have seen that Telex has a growth rate of 15% annually. Advancement of the TELENET computer controlled service is in direct response to the rising demand. TELENET will have store and forward switching, capacity for multiple address, and other features similar to requirements for a Data Transmission net. The service will include Data-Telex. It is possible that Telex will place increased emphasis in favour of the ASCII code to increase the potential of the system for low speed data service, as well as Record-Message. It will be seen in the following text that CN/CP Tel are planning to vigorously promote their Data Transmission facilities. These obviously can be developed to maximum advantage as an integrated system with Record-Message services.

TCTS state that about 80% of the TWX terminals are now Data oriented. It would appear that it is as a low speed Data transmission service that the system has a future. The telephone companies recognize this now in their sales policy, which is to sell TWX as a Data system. The Multicom data transmission system (introduced in 1970) provides a necessary extension of the speed range of Data service offered by TCTS.

6.2 Is Non-intervention Possible?

A competition is developing between TCTS and the CN/CP Tel to decide which is to establish the major Canadian Data transmission system and to benefit from the sale of its services.

Since the TCTS system now enjoys advantages which CN/CP Tel claim are rooted in monopoly, and are similar to those discussed for A.T.&T. in the U.S., it can be expected that CN/CP Tel will press for government intervention to establish a different environment. Keynotes in their claims will be access to the local switched public telephone network for private line voice, and low-medium speed Data, and protection for a public integrated Message-Record-Data system. Details are advanced in the following chapter.

6.3 Conclusion - It is improbable that the Government will wish to ignore these issues in which there are strong elements of national policy. Decisions will have to be made which will have a decisive influence on the development of the economy. Therefore it can be reasonably stated that a course of non-intervention is not open to the Government. Thus the first of the Terms of Reference is seen to be a hypothesis which can be discarded.

PART VII CN/CP TEL CARRIER TO CARRIER INTERCONNECTION PAPER *

7.1 Foreword

In considering the matter of carrier to carrier interconnection one must be guided by the basic premise underlying policies and laws governing Canadian industry and commerce; namely, unless inconsistent with public interest, competition is to be encouraged and relied upon to regulate the economy. Competition affords the most reliable incentives for innovation, cost reduction, efficient resource allocation and consumer protection against high prices and inferior products and services.

Most of the Canadian economy fits the competitive pattern. The pattern is not the classical pure or perfect competition model but a structure ranging from two to thousands of suppliers in respect of most products and for most customers, depending on particular technological and market circumstances. Entry into markets by new producers and new suppliers is permitted and encouraged. The purpose of the Combines Investigation Act, which prohibits restrictive trade practices, is to prevent the suppression of competition. In addition, the Criminal Code of Canada, contains provisions which declare as crimes against society the practice of certain restraints in industrial competition. Courts have long held in cases under these statutes that the public has a vested interest in the maintenance of competition.

National policy tends to minimize price regulation and other direct interference with free market forces and the economic initiatives of individuals and companies. Only where workable competition

* Copied verbatim from the original with added section numbers.

is not effective, or the result of workable competition is not in accord with public policy, is there direct government interference with market forces.

Telecommunications Services in Canada are presently provided by two main Carrier groups, the telephone system and CN-CP Telecommunications. Public telephone service is almost exclusively provided by the telephone system and public telegram service by CN-CP, with both groups competing for other services, mainly private services. Because of the size of the public switched telephone network (representing approximately 85% of all Telecommunication Service requirements) and the fact that CN-CP is denied access to this network for local distribution of its services, competition is ineffective. Nevertheless we advocate retention of this structure for the Telecommunication Service industry with modifications, described in this report, to strengthen competition.

7.2 <u>Summary</u>

Accordingly CN-CP submit:

(1) Two carrier competition in Canada is desirable for certain sectors of the Telecommunication market. Mainly these sectors include:

   (a) Dedicated private line service: voice, digital record, facsimile and telemetering.

   (b) Broadcast network service: audio and television.

   (c) Line switched service: digital record in excess of 600 bauds (the minimum speed at which digital transmission on a voice bandwidth may be justified), private voice and facsimile.

(d) Message switched record services for private use. The number of Telecommunication Carrier groups, presently the telephone system and CN-CP, offer the best compromise between economies of scale and competition and should be continued at this time.

(2) There should continue to be a monopoly in public telephone service.

(3) There should be a monopoly in public record service, whose integrity, reliability and viability should be preserved, to provide:

(a) Telegram services.

(b) Line switched (including equivalent quasi real-time systems) record services at terminal transmission speeds to 600 bauds. (Speeds which can be accommodated economically by telegraph circuits without resorting to a full voice bandwidth).

(c) Message switched record services involving store and forward switching techniques and operating at any speed dictated by current practice and the state of the art.

The public record system should include existing TWX, Telex, Data Telex, TelTex and Telegram services in an integrated network.

(4) In the public interest the monopolistic services will require regulatory constraints which are not needed for competitive services. In the latter case regulation must be sufficiently broad to promote fair and effective competition.

(5) To achieve fair competition regulation must prevent economic strength derived from protected markets in the monopoly field from being used by carriers to engage in unfair or destructive practices vis-a-vis other carriers in the competitive field. It

must preclude cross subsidization among various classes of service and in particular between monopoly and competitive services. Exceptions should be allowed for services to remote areas under development where the total demand for service is small (e.g. Yukon and NWT). In such cases all resources must be pooled to provide viable public services at reasonable prices.

(6) To achieve effective competition and to avoid wasteful duplication of local services, carriers must be allowed to continue to acquire local distribution facilities from an other carrier in order to access subscribers to their services. Furthermore to prevent monopoly power from denying competitive opportunities in private line services access must be allowed to local (metropolitan) monopolistic switched services. Such extensions and/or interconnection to local switched distribution systems should be provided at regular tariff.

7.3 The Rational of Limited Competition in the Canadian Telecommunication Services Industry

General - The rationale of limited competition stems from two premises. First, competition will insure that as the state of the art advances, users of telecommunications will enjoy continually improved and modern services at reasonable prices, with minimum government regulation. Second, limiting competition will permit the achievement of economies of scale in the Canadian environment to guarantee the attainment of this objective.

Benefits of Competition - The principal benefits of competition in the

Telecommunication Services industry as opposed to a monopoly are:

1) Stimulation of efficiency and encouragement of innovation -

   Competition affords the most reliable incentives for product and production innovation, cost reduction and efficient resource allocation -- that is, production at the level that will satisfy all consumers for whom the utility of a service exceeds the cost of supply.

2) Promotion of quality, reliability and good service -

   The possibility exists of compromise between service quality and reliability, and cost, but generally competition creates incentives for improved performance consistent with costs. These issues can be resolved in the market place.

3) Customer satisfaction from having a choice of suppliers -

   From the variety of services offered by competing carriers the customer can choose those which are tailored to meet his particular needs and is free to move to an alternate supplier if the service turns out to be less than expected.

4) Responsiveness of suppliers to new and specialized customer needs -

   Often, and especially in times of rapidly changing service needs, the services offered by monopoly carriers are highly standardized and relatively inflexible and impose an extra cost to some consumers-- the cost of adjusting specialized demands to general service offerings. An alternative supplier can:

1) offer specialized services to particular groups of customers permitting cost savings and avoiding waste;

2) use different and perhaps more advanced technology especially suitable for specialized or new service requirements;

3) be more efficient and faster in introducing new services.

5) Lessening of the need for government regulation and control - The levelling factor of competitive pressures generally lessens the need for regulation to achieve the broad policy goal of a wide availability of Telecommunication Services at fair and equitable prices.

6) Dispersal of economic control and decision making. Provided that there is effective competition with adequate regulatory controls to preclude cross subsidization and predatory pricing, economic control of the industry by one carrier can be avoided, widening the scope for individual and company-level initiative in decision making processes.

Limited Competition - The Telecommunication industry is characterized by a distinct set of economic conditions:

1) It is capital intensive and becoming increasingly so.
2) It has high threshold or constant costs and low marginal costs.
3) It has a high rate of technology change and obsolescence.

Because of these conditions and the inherent economies of scale, the industrial organization choice for the Telecommunications industry must fall between limited competition and monopoly. We believe that the course of limited competition is desirable in the public interest and compatible with the historical patterns Canada has followed in the public utility and transportation fields. The airlines and railroads serve as prime examples.

The present structure of the Telecommunications industry which consists essentially of two competing groups reflects the choice we advocate. The two groups are: CN-CP as one group and the telephone system which includes Bell Canada and provincial and regional telephone companies as the other. Ownership in the industry is predominantly private with one Federal and three Provincial Government owned carriers. Public telephone and public telegram services are operated as monopolies by the telephone system and CN-CP, respectively, with competition between these two Carriers in other service areas.

This carrier configuration has performed well and has met Canadian needs with wide availability of essential services at acceptable prices for the user. In the public utility sectors both carrier groups have been responsive to their public duty in their rate making policies. They have been able in the past to raise the necessary capital to provide the services needed and the performance of the present systems attests to the quality of their services. There is no evidence to suggest that the present two-competitive-group system will not be able to adquately meet anticipated telecommunication needs in the future, given the recommendations proposed herein.

Our recommendation for limited competition in the telecommunications industry is in conformity with accepted Government policy in the telecommunications industry and has its roots in similar national policies adopted in the past. Any departure from the existing industry structure must proceed with caution. It should define where the present system is failing and make changes only when there is no doubt that the changes will in fact correct such failings while minimizing undesirable side effects.

We reiterate that competition in the telecommunications industry should be limited to the number of suppliers necessary to realize economies of scale, efficient use of the frequency spectrum and to effect other efficiencies that will result in services becoming available to users at least cost. In view of present market sizes and technologies of production, the number of Telecommunications Carriers in Canada at this time should be limited to two.

The question of airline competition in a limited two-firm market was examined in a study by S.F. Wheatcroft completed for the Canadian Government in 1958, entitled "Airline Competition in Canada". A conclusion of the study was that the possible benefits of competition between two suppliers in stimulating more adequate and efficient service, technological progress, and traffic development and in providing the satisfaction of choice to consumers and a yard-stick for measuring efficiency outweighed the risk of competition's raising cost levels through stimulating over-capacity. The principal recommendations contained in the Wheatcroft report respecting competition were implemented by the Government and indeed have been expanded steadily since that time.

One of the major issues examined in the U.S. "President's Task Force on Communications Policy" dated December 7, 1968 was "determining the proper roles of monopoly and competition in the provision of telecommunication services". The study concluded: "The premise of our law with respect to industrial organization is that competition should be the rule, and monopoly the exception. Monopoly must be resorted to where a single seller is desirable as a consequence of conditions that permit him to offer most economically the full supply required by the market....In the field of domestic telecommunications, our public telephone service is such an example". In areas of the telecommunications industry "which do not, or need not, affect the integrity of the switched public message telephone network", the report recommended the removal of unnecessary restrictions on competition.

Although we do not recommend for Canada's small market the freedom of unrestricted entry proposed in the Task Force report, we do accept the principle underlying the recommendation; namely, that the achievement of economies of scale in the provision of particular Telecommunications Services do not require, for efficiency, a single supplier and that competition among suppliers will best satisfy consumer needs.

7.4 Monopoly Areas in Telecommunications

Except in certain areas of Newfoundland and the North West Territories which are served by Canadian National Telecommunications, public telephone service in Canada is provided by the member companies of Trans Canada Telephone System and other independent telephone companies. These telephone companies provide service in contiguous territories, consistent with their charters or enabling legislation and interconnect with one another to provide long distance telephone service. Except as indicated, CN-CP Telecommunications does not provide public telephone service and is not permitted by the telephone companies to interconnect with their switching facilities to extend any of its services.

We accept the position that it is in the public interest to have an integrated telephone system made up of individual companies offering public telephone service in a number of contiguous areas. Competitive offering of such service would involve an uneconomic duplication of facilities.

We contend that under present conditions the public telegram service is best provided by a single company. Because of rapid declines in usage, currently averaging approximately 6% per annum (in part due to the increased use of TWX and Telex services), business has reached a level that can hardly support one carrier. It was this situation that caused Canadian National and Canadian Pacific to abandon competition and pool their telecommunications resources to achieve all possible economies.

We also contend, for the same reasons applicable to public telephone service, that there should be a single carrier responsible for the provision of public record services, that is record services to which any member of the public can subscribe and by means of which any subscriber can transmit or receive record traffic to or from any other subscriber.

These record services should include specifically the existing TWX, Telex, Data Telex, TelTex and Telegram services, integrated into one network. Generally, the record carrier should have the exclusive responsibility of providing to the public:

(a) Telegram services

(b) Line switched (including equivalent quasi real-time systems) record services at terminal transmission speeds up to and including 600 bauds. These are speeds which can be accommodated by telegraph circuits without resorting to a full voice bandwidth (nominally 4000 H3), thus reducing costs by avoiding the unnecessary use of frequency spectrum.

(c) Message switched record services involving store and forward switching techniques and operating at any terminal transmission speed as dictated by current practice and the state of the art.

The 600 baud limit is specified in item (b) not only to reduce costs and conserve frequency spectrum, but also to prevent the establishment of a competing switched service over the public telephone (voice) network by merely changing the name of the TWX offering. This does not preclude use of the public telephone system by subscribers for the carriage of digital transmissions, except that such use should be subject to the same tariffs and rules as apply to the public local and long distance telephone services.

Item (c) seeks a monopoly of message switched services at any speed, to the extent only that the use of store and forward techniques are employed in the provision of a public record service as defined above i.e. that any subscriber to the service can transmit or receive record traffic to or from any other subscriber.

Similar to public telephone service, competitive offerings of public record service would involve an uneconomic duplication of facilities which is not in the public interest.

There is significant demand for public record services in Canada as evidenced by the size and growth of the Telex network. By the integration of existing TWX, Telex, Data Telex, TelTex and Telegram service the public will benefit from:

1) Increased call potential by bringing together the now segmented switched record services.

2) Access to public telegram service presently not available to TWX customers.

3) Cost-of-service savings.

4) Greater development of the public record system in terms of new services.

From the Carriers point of view, benefits accrue from:

1) Increased potential and stability in earnings.

2) Increased potential to plan and innovate services and pricing policies within an enlarged market.

3) Ability to make more effective use of public telegram service as an integral part of the public record system.

Some, but not all, of these benefits could be realized by interconnecting TWX, Telex, Data Telex and TelTex services as they exist. Interconnection is technically feasible by code and speed conversion. However separate ownership would not permit flexibility in planning controls and pricing policies or produce the potential cost-of-service savings possible in a fully integrated system, and is therefore an unsatisfactory solution. Specifically, it is recommended that TWX service should be absorbed by the Telex network as soon as a service similar to that available to TWX customers, can be provided. More particularly it is proposed that CN-CP assume the exclusive responsibility to supply line switched record services as a public offering for all transmissions at speeds up to and including 600 baud.

To effect integration of record services up to 600 baud a code and speed translation capability must be established. Having this capability and in recognition of the desirability of further integration of other digital services into a public record system, it is recommended that CN-CP assume exclusive responsibility for the use of store and forward switching techniques in the provision of public (record) services.

CN-CP have consistently demonstrated initiative and leadership with development of switched record services. They first recognized the public need for such service by introducing Telex in 1956, six years ahead of TWX, and for many years previously had been designing and installing systems for telegram traffic and private use. Computer based store and forward services were first offered by the CN-CP in 1964. They are now operating four independent systems serving nearly 1000 lines and 3000 outstations operating at speeds ranging from 75 to 2400 bauds. These systems include over 500 million characters of mass storage. Two additional store and forward systems will be placed in service before the end of 1970 and plans are already being made for new Telex offerings and the integration of Telex, Data Telex and other digital services using computer oriented switches.

Monopolies in public record service as previously defined, owned and operated by CN-CP, would promote healthy intermodal competition with the monopoly in public telephone service. It could stabilize and strengthen CN-CP's financial base and allow plant development to lessen, in part, the advantage held by the telephone system in their ability to realize economies of scale. In addition the exclusive responsibility to supply public service involving the use of store and forward switching techniques provides for inter-connection with, a similar system being developed by Western Union in the United States.

7.5 Competitive Services

The monopolies proposed in Section 7.4 are not inconsistent with the position favouring competition within the Tele-communications industry. Benefits flow not only from strong public telephone and record services but from healthy intermodal competition.

For some telecommunications services the special economic and technical considerations that overturn the presumption in favor of competition over monopoly are not present. Thus, where communication service needs do not require access on demand to any one of millions of points, some of the special problems relating to system optimization, integrity and reliability (that make the case for monopoly in public service) no longer operate. In all such circumstances the communications services can be more responsively and efficiently provided by competing suppliers.

In particular we believe the following communications service areas should be served competitively, that the number and size of competitors should be limited so that each can realize full economies of scale, and that the limited competition should be subject to government regulation which precludes cross subsidization and protects against unreasonable prices:

1) Dedicated private line services: voice, digital record, facsimile, and telemetering
2) Broadcasting network facilities: audio and television.
3) Line switched services: digital record in excess of 600 bauds (the minimum speed at which voice bandwidth may be justified from the standpoint of economy and spectrum conservation), private voice and facsimile.
4) Message switched record services for private use.

In these areas competition already exists between the telephone system and CN-CP.

All of these services are effectively private services in that they are leased by a person for use between specific terminals. Even the line switched services have restricted connectability, limited to compatible terminals and the speed capabilities of line facilities.

The telephone system has been handling line switched digital record services on their public telephone network, at speeds within its technical capability. We contend that services at speeds up to 600 baud can be more efficiently handled on less than voice band facilities and should be integrated into a public record system. This does not preclude public telephone service from being used by subscribers for this purpose, (or any higher speed) as long as tariffs and rules for public telephone service apply.

CN-CP offers its Broadband network service for data transmission speeds in excess of 600 baud. Unlike the public telephone network, Broadband provides for simultaneous two-way transmission and for some time has been offering switched services at speeds up to 4800 baud on specially conditioned voice band facilities. However, the network has been designed to switch various bandwidths up to 48 KHz, for which data equipment is available to handle 50 kilobaud speeds. The continuing growth of this network since its inauguration in 1967 has demonstrated its acceptance by the business community and is a prime example of why a competitive environment should be continued in the line switched broadband services.

Without terminal compatibility, code and speed conversion of digital traffic on these networks is necessary to allow record traffic to flow from a terminal to any other terminal. This involves storage and retransmission (store and forward). Our position is that the application of this technique to provide a public record service should be restricted to preserve the integrity, reliability and viability of such a service. We moreover believe that CN-CP should have responsibility for the service in view of its complementarity to the low speed record service for which a monopoly is proposed to CN-CP. Moreover, a CN-CP monopoly in store and forward service will help provide a business base to the vastly weaker competitor in the telecommunications area.

Conversely the application of such techniques for private message switched record services should be competitive. Requirements are developing rapidly and the public will benefit from active competition where competitors must use every resource available to capture a fair share of the market.

It is significant that the requirement for data transmission services in Canada is at the threshold of significant development. The potential for added competition in telecommunications from developments in this area is great. As a result of social and technological changes already on the horizon, there will emerge in the 1970's and 1980's an ever increasing requirement for customers information processing and storage and retrieval services. By 1975 experiments will have begun and some systems installed permitting home owners to access computers for various purposes.

Many benefits will accrue from active competition provided that the competition is effective. In this respect it is important that Carriers be precluded from taking advantage of favourable returns from monopoly service areas to subsidize marginal or loss situations in competitive markets. To this end there is a need for effective (but not restrictive) regulation. It is important also that no undue advantage be taken of monopoly situations to create unequal opportunities for competitive services. To this end there is a need for policy decisions concerning carrier to carrier interconnection of facilities and services.

7.6 Regulation

As we have seen there are two primary Telecommunications Carriers in Canada today, the system of telephone companies and CN-CP Telecommunications. In 1968 all Carriers grossed 1.385 billion dollars in revenue of which over 90% accrued to the telephone companies, primarily from monopolistic telephone services. In the order of 150-200 million dollars was derived from other services, largely private line services which is a major competitive segment of the Carriers' business and from public telegram and cable services. The following are statistics taken from the 1968 Dominion Bureau of Statistics report (DBS) and the Carriers Report on Telecommission Study 2(e).

Canadian Telecommunications Industry Revenues 1968

(Millions of dollars)

Telephone Companies

Exchange telephone services, directory advertising, income from investments, local private line and service charges.	760

cont'd

Telephone Companies (cont'd)

Inter exchange switched network long distance and TWX message charges	430
Wats, inter exchange private lines, message switching data services and Telpak	78
CN-CP	
Public telegram, private line services, Telex, and Broadband	83
COTC	30
Others	4
Total	1,385

At the end of 1968, DBS also record a gross capital investment in excess of 5 billion dollars for the telephone system compared to 400 million dollars for CN-CP. Since the two competing carrier groups cover essentially the same geographical area it is clear that competition is nominal and ineffective.

The fundamental principle of regulation should be that the rates charged for a Telecommunication Service earn a fair return, at least sufficient to meet the costs of provisioning. This should not preclude rate averaging in the case of a particular service provided that it is in the public interest.

With a system of regulation based on the criterion of fair return on the entire rate base of a Carrier, such as applies to Bell Canada today, the possibility always exists that the Carrier could use its superior position in sheltered markets to cover losses or marginal profits in competitive sectors. We contend this is not in the public interest.

In this regard it is worth noting the results of the Federal Communications Commission's Seven-way Cost study undertaken in the United States a few years ago in an effort to determine the earning levels of particular interstate services. The Bell System was requested to undertake an extensive inquiry to ascertain its interstate investment, revenues and expenses and net earnings, among seven categories. Detailed procedures were developed for the allocation of investment and expenses among particular categories of service, generally based on the principle of relative usage. Analyzed in terms of total day usage for a 12 month period from Sept. 1, 1963 to Aug. 31, 1964 the following results were reported:

Category of Service	Net Operating Revenues (thousands of dollars) (A)	Net Investment (B)	Percentage of A to C	Percentage of A to B
Message Toll Telephone	426,723	4,286,702	86.7	10.0
Teletypewriter Exchange Service	6,795	237,584	1.3	2.9
Wide Area Telephone Service	30,684	303,004	6.3	10.1
Telephone Grade Private Line	17,137	362,758	3.5	4.7
Telegraph Grade Private Line	4,414	313,324	0.8	1.4
Telpak	1,662	564,742	0.3	0.3
All Other	5,174	490,292	1.1	1.1
Total	492,589 (C)	6,558,406	100.0	7.5

Reservations or limitations believed pertinent to the findings and set forth in subsequent testimony, were noted by the examiners but did not invalidate or alter the success with which the study achieved its intended purpose. It was clearly evident that only the percentage of net revenues of message toll telephone and Wats to net investment exceeded the percentage of total net revenues to total net investment and that all the remaining services fell below the average return. Western Union charged that the Bell System used its monopoly voice services to subsidize its competitive telegraph and private line offerings.

Clearly, effective competition cannot exist under such conditions in Canada or in the United States.

7.7 Interconnection

Telex and TWX - As we have seen in Section 7.4, there are substantial reasons why the integration of TWX and Telex would be in the public interest. From the users viewpoint an important consideration is to overcome the isolation of some 3000 TWX subscribers from the mixed business Telex community of 20,000 subscribers. In addition TWX subscribers by joining Telex would have access to local telegraph offices and to TelTex service to complement their record handling capability. There are however more compelling reasons to integrate these two networks or more specifically to absorb TWX service into the Telex network.

With the acquisition of TWX by Western Union in the USA, Canadian Telex will also access American TWX. Therefore, from the traffic and community of interest standpoint it is clear that TWX subscribers should be added to Telex.

TWX service as presently provided does not have its own long distance switching plant. It uses the same facilities as the long distance telephone service. Even so charges for TWX service are lower than long distance telephone charges* and are not subject to a two/three minute minimum charge. This clearly suggests that TWX services are subsidized by public telephone users.

On the other hand, Telex service uses telegraph long-line plant which occupies just enough frequency spectrum to render reliable service dictated by the speed desired. If Telex were not a viable system it could not mask its deficits with profits derived from captive customers using the same network.

Furthermore, while TWX operating at 110 baud requires a full telephone channel (4000 Hz), 110 baud Telex uses 340 Hz. This bandwidth wastage of frequency space is reason enough for transferring TWX service to a network specifically designed for the teleprinter speeds required.

It is important that the legislators insure that the portion of the spectrum assigned to public long distance telephone system is not wasted. To this end we recommend that the public long distance plant be used only at speeds exceeding 600 bauds. In addition to avoid cross-subsidization and to simplify regulation, any digital service offered by the telephone companies over their public long distance network should be subject to the same tariff charges and rules as applicable to long distance telephone service.

* TCTS state this to be true only in some cases.

In our view there are overwhelming advantages in favor of transferring TWX subscribers to the Telex community operated by CN-CP Telecommunications. The most important, from the user standpoint, is the availability of a completely integrated record service paralleling the voice service offered by the telephone companies.

We believe it to be in the national interest to protect the telegram service in Canada. Many users cannot afford other more expensive substitutes and for many purposes the telegram is the most satisfactory way for these users to convey records from one point to another. To automate record handling and offer an alternative to telegram service, CN-CP introduced Telex in 1957, a form of do-it-yourself public message service. This meant that large telegram customers adopted Telex which greatly reduced the volume of public telegrams without a corresponding reduction in operating costs. However, additional Telex revenues and an improvement in service were sufficient incentive to continue our efforts to convert telegram users to Telex service. TWX came into being six years after Telex and contributed further to the erosion of Public Telegram volumes. But, diversion of customers from Public Telegram to TWX has meant greater deficits in the provision of telegram service without compensating revenues. An integrated record system, provided by CN-CP would correct this situation and strengthen the public telegram service.

The foregoing clearly shows that the public interest will best be served by integrating TWX and Telex under one administration. It is also clear that this administration should be CN-CP Telecommunications.

Private Line Services - For CN-CP to achieve the goal of effective competition in the Telecommunications industry in Canada, two primary conditions regarding interconnection with the telephone system's plant and service must obtain:-

1) CN-CP must have access to dedicated local distribution facilities (loops) as long as they are provided exclusively by the telephone companies.

2) CN-CP must have access to public switched telephone networks for local extension of their private line services.

The converse is equally applicable for the telephone system, given that CN-CP has a monopolistic public record system. The telephone system must have access to the public record system for local extension of their private line record services.

At this time the telephone system has developed a vast system of distribution facilities (loops) for local extension of its public telephone service. Since these facilities can be used and are used for local distribution of many other Telecommunications services, it is in the public interest that unecomomic duplication of these facilities be avoided. CN-CP has recognized this public interest by adopting a policy of acquiring local loops from the telephone system rather than constructing their own facilities where adequate transmission capabilities exist.

Since all Telecommunications Services originate and terminate on customers premises, it is axiomatic that as long as local distribution facilities are provided by a single carrier, any competing carrier must have the right of access to these facilities at reasonable rates. The right of access should be guaranteed by law.

In addition if a carrier providing a public switched network permits interconnection of any of its private line services to any part of such networks, a similar right of interconnection for the other supplier of private line services must be required to afford equal competitive opportunities to both Carriers in the private line service area.

Specifically, to afford effective competitive opportunities for private-line voice services CN-CP must have the right of access to local telephone exchange facilities. Telephone companies' private line voice services may interconnect with the local public telephone network at any customer terminal. As this additional service is denied CN-CP customers, the Telephone companies have an unwarranted advantage. The absence of such access puts CN-CP on a wholly unequal basis and renders competition between the two Carriers a mere illusion.

To avoid misunderstanding, we do not seek nor envisage entry into the public telephone service market, but rather urge the introduction of effective competition for private line services. We acknowledge and respect the need, in the interest of the public to preserve the integrity, reliability and viability of the public telephone system. Specifically we seek the right to extend our private line services from a subscribers terminal into the local (metropolitan area) switched telephone network on the same basis that the telephone system now permits extension of their private line services.

This is of particular significance today as many users of Telecommunications Services contract for service of various types, in large quantities, as a total package. The ability to use total service capability is a prerequisite to effective competition. The inability of CN-CP to provide private line voice services along with record services on an equitable basis with the telephone companies automatically stifles effective competition in a substantial segment of the market which should be truly competitive. With the expanding demand for bulk telecommunication services, it is essential that CN-CP be in a position to capture its fair share of this market and achieve economies of scale available to the telephone system. Failure to do so will inevitably reflect on its ability to competitively price its private line and exclusive services.

Opposing Arguments - The traditional arguments one encounters against interconnection center on interference with average cost pricing and "cream skimming". In respect of the average cost pricing argument, it is often stated that provision of local and long distance telephone services have been intermeshed and their pricing designed to average out inordinate disparities with the result of more people having more reasonable priced services. It is probably true that revenues from long distance services subsidize local service, to a degree, resulting in lower rates for local users and higher rates for long distance users. Interconnection will introduce competition in the over-priced long distance monopoly.

The argument that interconnection will give rise to "cream skimming" is not without some validity if traditional communications services pricing policies based on system-wide costs, continue to prevail. However, the pricing of communication's services may, and perhaps ought to be, based on specific costs of serving specific markets. If competition is to yield improved efficiency in communications supply, which we contend, then there is cause to question the traditional policies and consider the alternative that pricing should be related to the markets involved.

We contend that the market for private line telephone service need not be integrated economically with that for public telephone service and that rates established for such services should be based on costs and demand. This view is not inconsistent with the position that the integrity, reliability and viability of the public telephone systems should be preserved. Likewise, it is consistent with the situation proposed for a public record system wherein similar arguments with regard to cream skimming can be advanced.

The degree to which prices may rise for local telephone service, the basic criticism against interconnection, is difficult to judge because no data are available on the extent to which cost averaging takes place. Nevertheless it is inconceivable that local rates for public telephone service would be substantially affected by increased competition for private line services in view of the relative sizes of public and private telephone markets. As shown in the report of the "Seven Way Cost Study" in the United States, (Page 84 herein) the ratio of earnings from these two markets was approximately 25:1 in 1963-4 favoring the public telephone service. Granting subsequent changes in these figures from revisions in tariff structures and changes in demand, it is considered that a similar order of difference applies today in Canada.

In conclusion we believe that the public interest will be served by CN-CP Telecommunications having the opportunity to compete for new business and a fair share of future business growth. Continuing success for both CN-CP Telecommunications and the telephone companies would confirm our belief that Canadian users not only want the ability to choose between suppliers but seek the benefits accruing from competition.

PART VIII TCTS CARRIER TO CARRIER INTERCONNECTION PAPER

The following is a verbation reproduction of part of the TCTS paper with added paragraph numbering. The remaining part on TWX-Telex has already been introduced in Part V and studied in Part VI.

8.1 Introduction

This submission on behalf of the Trans-Canada Telephone System deals with the problems which would arise if interconnection of the service offerings of competing common carriers became general as opposed to the leasing of facilities between such carriers.

The term "interconnection", in this context, implies joint provision of one "Service" for the user, or users, of such "Service".

"Service" falls into two broad basic classes:

8.1.1 "General Public Telecommunications Service" is one to which any member of the general public can gain access to any subscriber of a telecommunications network standard schedule of rates.

8.1.2* "Private Line Service" is designed to meet the private needs of specific customers for communication between prescribed points and to which only they shall have access.

* See note page 98

While most of the current telecommunications service offerings may be considered as either "Public Telecommunications Service" or "Private Line Service", some service offerings may not seem to fit either definition precisely, for one or more reasons. For example: tie trunks between Private Branch Exchanges, and Foreign Exchange Services, may appear to have "private line" characteristics, but, in actual use they are part of general public telecommunications service.

It should be noted that the term, "Private Line" has been used in the industry for a great many years. It probably originated as the name for a pair of wires with a magneto telephone at each end. Use of the term has evolved, however, to describe a number of entirely different services. For example: Basic residence telephone service is provided by individual line, two-party line or multi-party line (usually in rural areas). The vast majority of users call their individual line a "private line."

Teletypewriter service that is point-to-point, or multi-point, as opposed to switched service (Telex and TWX) is "Private (Wire) Line Teletype."

"General Public Telecommunication Service", insofar as the switched telephone network is concerned, has, over the years, accommodated progressively more special telecommunication requirements or in the broad sense, "Data." Early examples included transmission of photographs by the so-called "Telephotograph" technique, and dial-up access to recording devices that report, for example, water levels in a storage reservoir, time of day, weather forecasts, etc. In recent years, with the development of a wide variety of terminal devices and data interfaces, the switched telephone network serves both digital and analogue data applications which range for example, from the transmission of electro-cardiograph tracings, facsimile, to handwriting via "Electro-writers". These are, in effect, alternate uses of the network's capability.

As additional requirements are identified, the telephone network is adapted to accommodate current and future needs. This involves switching as well as transmission capability.

By utilitizing the basic components of the network - such as rights-of-way, supporting structures, buildings, power, etc. - plus available design, installation and maintenance capability, the result has been that expanding telecommunication requirements are accommodated with efficient use of resources and technological advances.

An obvious example is the manner in which network television facilities have been provided in Canada.

The optimum situation in any telecommunications "network" is to have responsibility and accountability for the "network" vested in a single entity.* The Trans-Canada Telephone System, with its common standards of service, design and operating parameters, closely approaches this ideal situation.

* See also Study 8(b)(i)

8.2 Interconnection

Let us now examine "interconnection" of the services of competing common carriers, and try to identify the extent to which such services are now "interconnected", and the need, if any, for such interconnection.

Basically, "systems" are designed to provide optimum performance, end-to-end. To date, in Canada, there are comparatively few cases where "systems" are interconnected.

Where such cases do exist, the circumstances are, or were, quite different from the requirements of the vast majority of users of telecommunications services. Two examples of carrier to carrier interconnection are: -

8.3 Telecommunications For Defence

In some areas of telecommunications required for the defence of Canada, the common carriers supply a variety of facilities which, in addition to providing route diversity, are, in some instances, interconnected parts of an overall "system". An example is the Canadian Forces Switched Network (CFSN). The telephone industry provides the switchers, but not all of the trunks and access lines.

8.4 Radio and Television

The common carriers are involved in four main contracts for the provision of the transmission facilities that comprise the existing Canadian broadcasting networks - CBC Radio, CBC Television (English & French), and CTV Network Ltd.

Interconnection for the more sophisticated quality service that television demands is rare indeed. Within the industry, such interconnections are considered undesirable because the involved common carriers engineer and design to somewhat different specifications, and each such interconnection requires that both the audio and video channels be brought down to baseband frequency, with some degradation occurring in both signals. On faults of course, there is still the need to ascertain which common carrier is the contributor, so that service can be maintained.

The telephone industry holds the prime contract for the provision of the CBC Radio Service to some 340 stations, over 25,000 miles of transmission lines. Because of the scope of this service, covering as it does a number of remote communities, many segments of this network service have been provided under sub-contract by other common carriers, principally CN/CP Telecommunications. The interconnection of these facilities, normally a 5KHz program line, between one carrier and another, does not present any appreciable problems - other than the sometimes contentious one of tracing faults so that the responsibility for the trouble can be clearly identified.

Because of the special nature of these facilities that are required by the broadcast industry, and the substantial investments involved on the part of the common carriers, the manner in which facilities have been made available appears to us to have been a reasonable approach.

There are a limited number of other situations in which the facilities of the common carriers are interconnected in a working system. These usually involve special circumstances applying at the time and, generally, meet requirements in the area of defence or emergency use in the interest of public safety.

We are now going to discuss some services where there is no carrier to carrier interconnection: -

8.5 TWX and Telex (see PART V)

8.6 Private Line - Voice

* In the case of Private Line - Voice, the user has a choice of supplier, although this may be limited by the availability of facilities between some service locations.

The TCTS Companies believe that lines of this type are primarily bulk-rate voice message and, as such, should continue to be supplied competitively, with no connection to the general switched network or interconnection between competing carriers.

8.7 Private (Wire) Line Teletype

Private Line Teletype is provided competitively by the common carriers in most parts of Canada.

There appears to be no evidence to suggest that interconnection of this service would benefit the customer of the common carriers, or that lack of interconnection has impaired overall development.

We recommend that the Private (Wire) Line Teletype Services of the competing carriers should not be interconnected.

* Private Line - Voice is considered as a public telephone service by the Telephone Companies and regulatory bodies in Nova Scotia and Prince Edward Island. As such it does not qualify under the definition of private services in those areas.

8.8 Broadband Exchange Service and Multicom

These competitive switched services are designed to serve data transmission requirements in medium and higher speed applications. Their basic designs are for end-to-end system operation, and, as designed, they are incompatible with respect to mix, or interconnection.

Both services differ from the switched telephone network in that they employ 4-wire switching, end-to-end, rather than 2-wire, and meet more stringent performance characteristics required for data transmission.

Both have voice capability, a useful feature for setting up and supervising data system transmissions. Because of their voice capability there is no effective way to restrict these services to the transmission of data only.

To the extent that they are used as a substitute for public message voice, such use erodes growth of public message voice service by "cream skimming" the higher density routes (and not serving) the less attractive routes) and can only work to the detriment of the public telephone network and its users.

The problems associated with "cream skimming" and discriminatory pricing are discussed in detail in Telecommission Study 7(ab).

Consequently, neither MULTICOM nor BROADBAND EXCHANGE SERVICE should be interconnected with the public message voice network.

As to interconnection, one service with the other, while their system designs are incompatible for end-to-end operation, it is technically feasible to make them work together but the cost would be substantial.

At this stage of development in the volume of data being transmitted in Canada, there appears to be merit in having competitive service offerings.

8.9 General

The Trans-Canada Telephone System makes its extensive local distribution facilities available to CN/CP, to facilitate the serving of CN/CP customers. In effect, the use of this valuable asset is shared, but the investment risk is not shared.

In addition, the widespread inter-city facilities of the telephone industry may be used by CN/CP to "piece out" their customer services, as required. The arrangement is a reciprocal one, although the "piece outs" supplied by the telephone industry tend to be on lower density, higher cost routes.

These arrangements reduce unnecessary duplication of basic telecommunication structures.

8.10 Conclusion

In general, it is the opinion of the Trans-Canada Telephone System members that interconnection of competing common carrier service offerings is not warranted, either by benefits to the vast majority of telecommunications users, or to the common carriers.

Any unusual situations that may develop, where interconnection might appear to be appropriate in the public interest, should be examined, considered and resolved by the competing common carriers, jointly, in a mutually responsible manner.

PART IX COMMENTS ON INTERCONNECTION PAPERS

9.1 General

The total satisfaction with the status quo as expressed by the TCTS position paper, suggests a position which is remarkably static considering the driving problems behind the strong controversies in telecommunications that exist just across the international border. Perhaps the Canadian government is just a little behind the FCC in opening new doors. Certainly the CN/CP Telecommunications paper takes this view, for after a preamble advising the continued acceptance of the general principle of competition within the industry, it vigorously supports new services concepts based upon a new monopoly form, and upon opening up of interconnection practices. On the other hand there are those who believe that the doors should remain locked.* Some details of each of the papers can stand elaboration for clarification or to bring out the less evident inter-relationships.

9.2 CN/CP Tel Paper (PART VII)

Ref Section 7.3, citation of the report on "Airline Competition in Canada" as an indicator of a direction for Canadian telecommunications is noted. There is a multitude of differences between the specifics of the two situations. The major difference is the relative stability of the telecommunications networks compared to aircraft routes.

In the last paragraph there are two important themes that are undeveloped. First, "freedom of unrestricted entry" currently amounts

* See President's Task Force on Communications, Final Report, Dissent by James D. O'Connell.

in the U.S. (and could here in Canada) to an out and out battle between the telephone system and entirely new companies such as DATRAN and MCI (see also Part IV) for the possession of the Data networks in the U.S. Now CN/CP Tel are submitting the possibility of starting a Canadian battle, restricted to two factions. TCTS will counter, with little prompting, that Canada cannot afford to experiment with federal policies which could lead to any sort of conflict. Secondly, note the phrase "in the provision of particular Telecommunications Services, etc...". CN/CP Tel are proposing instead it would seem, to obtain a particular share (i.e. the public segment of all non-voice services below 600 baud) of many services.

Supplementary to 7.4(b)(c) one may add by way of definition, line switched services might be defined as those in which after the initial connection has been made there is no further delay in transmittal of the message (except for propagation time which is not perceptible to the receiver). Message switched services with store and forward techniques can introduce controlled delays for many purposes. They involve storage media in the switching system.

It is essential to recognize that this paper uses the term "Message-Record" in the modern sense, i.e., to mean any recorded form of message be it a paper printout and/or a store in a computer. Therefore, the monopoly under discussion includes all forms of non-voice communications in the public switched network sense, except for the 600 baud rate limitation. Specifically, this blankets the low speed public switched Data transmission field which has been emphasized in Part VIII by TCTS, as being essential to a successful build-up of their Data services. Owing to the versatility of computers and their terminals there is no practicable way of policing a split between messages which are computer oriented and those which are not. A computer terminal will printout an ordinary conversation, and a computer can be used to switch between various terminals on its network. If there has to be a split between the services offered by the competing carriers a practical (technically) method is to set a baud rate as the dividing line. This is the method proposed for the division of services between W.U. and A.T.&T. as noted earlier, although the rate selected in that case is to be 300 baud. The selection of 600 baud by CN/CP Tel has merit.

Note, however, that the recommendation that "CN/CP assume exclusive responsibility for store and forward switching techniques in the provision of public (record) services" would eliminate competition in this message switching field unless the phrase "up to and including 600 baud" is appended thereto.

Section 7.5 continues to expound on the dividing lines between monopoly and non-monopoly type services. The argument is advanced that a distinction can be made on the basis of the smaller number of points for connection.* A monopoly also might equally well be accorded to either of two groups, one of which was much smaller than the other. Even classes of service become very hard to separate when computers are employed and hence the final resort to speed as the only 'break' point in controlling a telecommunications monopoly.

* top of page 84.

"Interconnection will introduce competition in the over-priced long distance monopoly" is a statement, which like an iceberg, conceals nine-tenths of its body. In comparing long distance rates between the two carriers one must first of all compare systems. It is understood that the concentration of the CN/CP Tel capital investment is in main trunk routes, whereas TCTS have in addition a very large investment in feeder trunks and particularly in toll exchange (switching facilities). TCTS argue that CN/CP Tel through 'piece-out' agreements have full access to the TCTS feeder trunk* and exchange plant without capital risk. They also argue that the cost effectiveness of the larger system is inherently less than the particular services owned by CN/CP.

9.3 Comments on Part VIII TCTS Paper

The reference to abandonment of the investment of equipment in use once service was discontinued, voices a serious point or not, depending upon the case being considered. Abandonment of the Telex investment would be serious, whereas it would not be so for TWX.

The discussion on private-line voice is so brief that the reader is left wondering just what element of competition is left in this region. The position taken by the two Maritime Provinces is that there is, and should be, none. CN/CP Tel say that without access to the public switched network a competitor has little chance.

* According to CN/CP Tel this is reciprocal in full.

The second paragraph in 8.1 and the first in 8.5 both make statements implying that users of low speed data services become adapted to a particular transmission system such that it becomes a wasteful expense to change. Exception can be taken to this point, which is not a very strong one. One cannot discount, however, the value of the initial sale to a customer, who providing he is satisfied, usually becomes "your man".

In general one must accept the fact (which has been ably argued by both parties) telecommunications services are most economically designed and built as systems. In a few years time, as these networks for Record, Message and Data services grow, interconnection costs (see 8.8, page 102) could be prohibitive. Segments of the economy would be artifically separated by a communications blockage which could only restrict growth of commercial, financial and industrial institutions and services. We all know that 'static' does not apply to our society. The competing Broadband and Multicom services will continue to grow. TCTS in other papers submitted to the Telecommission, support a one-system concept, and also other devices such as vertical integration to support system economies of scale, etc., but now in the case of new non-voice services, endorses limited competition, and also the fabrication of separate physical plants.

9.4 Conclusion

These comments have been designed to show two things. First that if the subjects were all treated in depth it would be seen that for every argument of the one party there is a counter argument at the command of the other. In such a situation decisions almost certainly must be arbritrary. Secondly, is 'Interconnection' the major issue? In some cases where a considerable amount of plant has been invested in two systems it may be. It is believed that from technical and operational considerations interconnection in general would introduce many costly new problems. It is just this that points to the old adage that 'prevention is better than cure' and therefore it is time for the Government to pause to consider whether the two-system concept is to be endorsed for those new services such as Multicom and Broadband (or say Data Services in general) where the specific plant investment to date is not such as to inhibit decisions for the best interest of the country.

Lastly, a third point must be raised and this is that in these papers there is no insight given into the future development of the technologies under discussion. It is known now for example that neither Broadband nor Multicom as a system meets the standards of switching performance which will be required for mass Data transmission. If other newer systems are to appear in this decade of what use is it to make recommendations which may take years to effect, and which will be concerned with only present day techniques? In PART X an attempt is made to widen the perspective on these problems by constructing a timetable for communications technology.

PART X WHAT WOULD BE BEST IN THE PUBLIC INTEREST

10.1 Western World Developments

We have seen what has happened in the U.S. where studies instituted by the U.S. government, on both economic and technical problems in telecommunications, have been in progress since 1965. These have resulted in a decision to decree* that there will be at least one Integrated-Message-Record-(Data) transmission system in the U.S. Furthermore this system will be outside of the telephone network. It will be technically and economically controlled by a single organization.

It will be useful to complete the overview of what is happening elsewhere in the Western World, namely in the U.K., France and West Germany. Canada must seriously consider developments in all of these countries in order to keep in step with the world telecommunications environment.

10.1.1 United Kingdom (UK) - In the UK, two institutions are actively studying and experimenting with Data transmission problems. These are, the National Physical Laboratory, and the Post Office, the latter now being a Crown corporation. A market study for transmission to effect a 15 year forecast was instituted by the Post Office in 1968. Twenty-five sectors of industry were studied as well as of the local and national governments. The consensus was that the 'seventies' would see a high growth rate in demand for data services e.g. by 1978/9 (allowing the usual provisions for error in such figures), 234,000 subscriber terminals are forecast. It was also concluded

* Not finalized as of Aug. 10/70. Re Data see 4.5.6

that most outstation terminals would have a data bit rate up to 10-24 Kb/s. (This is the hi-speed data range.) The National Physical Laboratory has an engineering model of a very advanced data transmission system under test now. The Post Office has active plans to install trial Message-Record-Data systems before 1975. Such systems will be all digital and will not attempt to make use of the telephone network except possibly for subscriber loops where special metallic pairs would be used. The Post Office policy will be to discourage inter-working of the Data and telephone networks until the distant future when hopefully there will be a single network containing telephony and non-telephony signals. The necessity for interfacing on a limited scale, at all times, is however recognized. It is envisaged that the new Data network would carry future expansion of the Telex network. Thus the U.K., as is the U.S., is opting for a separate Telex-Data network. In the U.K. of course all service is under the control of the Post Office. It is therefore easy to commit to a single system only, whereas the U.S. due to various pressures, has additionally opened the door to a proliferation of Data only services.

10.1.2 France - The situation in France parallels but lags that in the U.K. Trial integrated systems between selected cities are in the works. A Common Market group study indicates no likelihood of wide scale integrated digital systems before 1990. It also sees the end of the electro-mechanical, analogue telephone era as the first decade of the next century. On the other hand, growth rate of Data services currently is 100% per annum, a rate which is bound to force many changes. Telex growth rate is 15% annually. Separate digital and telephone systems are foreseen in this century as a matter of economic and technical necessity because the demand for telephones is so urgent that a delay in expansion of voice services due to introduction of digital technology cannot be tolerated.

10.1.3 West Germany - This nation has a different situation. The German Post Office, using the Siemens organization, is moving aggressively. There is a firm commitment to have an Integrated Message-Record-Data System operational by 1979 between most of the major cities. Trial systems will start in two years. Siemens have in the works production prototypes of a new Electronic Digital Switch (EDS) which is to be the backbone of the new system. (Note: Western Union have ordered an EDS system for earliest possible delivery). The new system will be additional to the telephone network. The Germans see little likelihood of matching with the telephone network before 1985-90.

In summary then, Canada's western*neighbouring governments have completed studies, conducted experiments and have advanced operational plans during the four or five years preceding 1970, and in a manner unmatched by Canadian government departments. All of the neighbouring governments have made commitments to establish and make operational in the 1970s if possible, new systems designed to provide facilities for the advancement of computer technology in their economies.

10.2 Communications Technology Timetable

To further implement the overview, a chart (Fig. 6)

* What of Japan? No first hand information is available.

COMMUNICATIONS TECHNOLOGY
TIME CHART

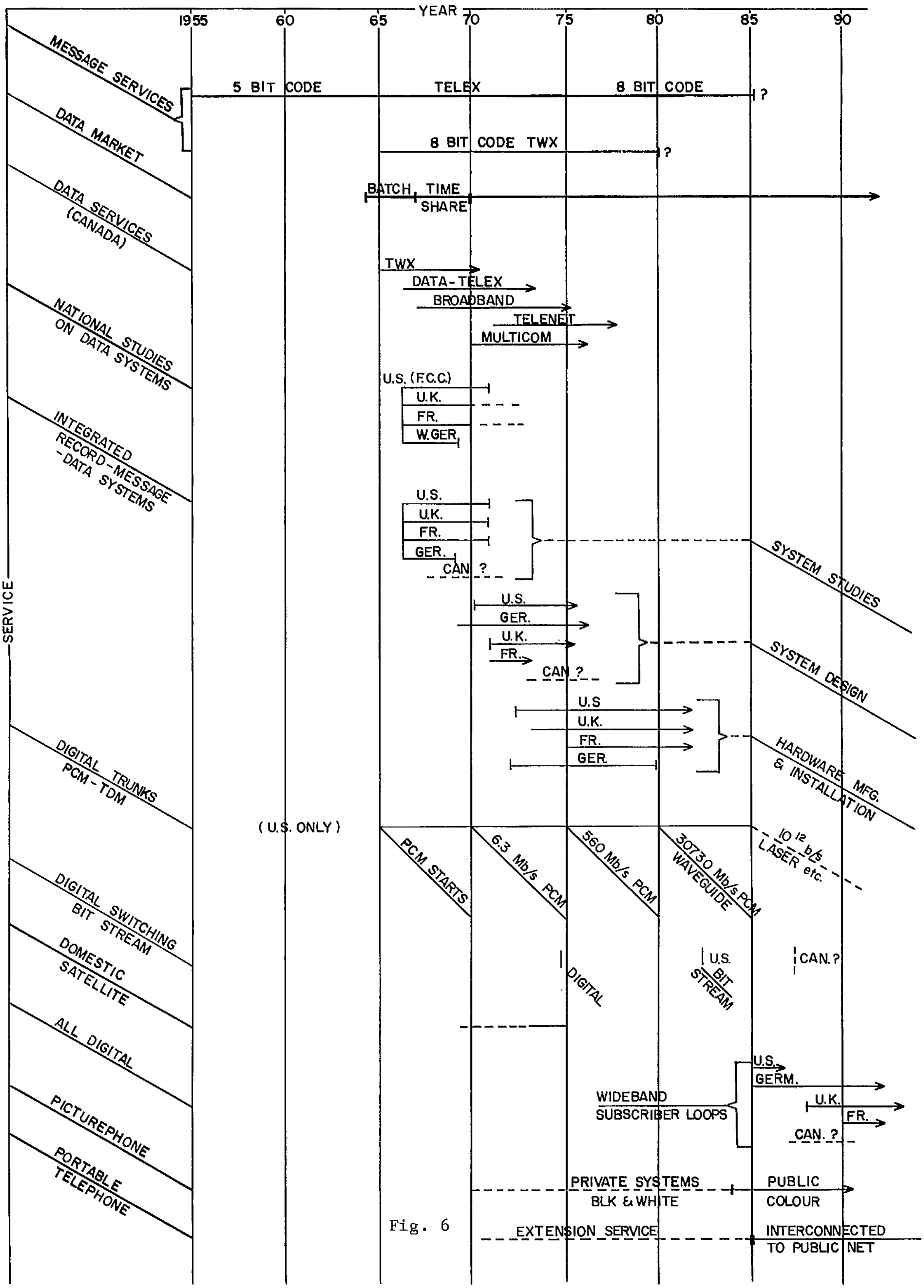


Fig. 6

has been prepared to illustrate this development of all of the new communications services and especially those under discussion in this text. The purpose is to show that all services from Telex to videophone will be involved in the evolution of digital transmission systems, and to suggest therefore that decisions made currently for any particular service should be made with long range developments in mind. Of course such a chart reflects opinions from various authorities, which vary +50% to -20% with regard to increments on the time scale. However it is necessary to recognize that the events shown are not only possible, but also probable. It is interesting to note that American observers will say that the European states* are ten years behind the U.S. and that Canada is five years behind. These remarks are probably true with regard to telephone services in Europe, but there is a definite possibility now that some overseas countries will leap-frog their telephone problems, into equivalence with U.S. technology in data transmission.

Before scanning the chart, attention of the reader is drawn to a few of the elements which will characterize the ultimate telecommunications system required for data, and also for voice, if the two are ever to be compatible. These elements are:

Trunks	code speeds (bits/sec) pulse code modulation (PCM) for digital trunks
Switches	digital switching digital bit stream switching (PCM-TDM)
Subscriber loops	wide bandwidth

* Essentially, west of the "Iron Curtain"

Starting at the top of the chart it is seen that in Canada, Telex is an early system. It has developed using a 5 bit code in a d.c. mode which is too limited for Data services. A suggested code transformation is indicated in the seventies. TWX has always used an 8 bit code. (Actually, at least 8 bits will be required for data systems and codes using 11 bits at least may be predicted to emerge.) It would be a reasonable guess to say that each system will be sufficiently transformed by 1980-5 to have lost its original name and identity because of development of digital technology. The first two lines on the chart represent teletype message-record service for the first half of the period with introduction and build-up of the low speed Data function for the second half.

Only Batch processing and Time-Sharing are highlighted in the Data Market. From 1970 onwards the market presumably will build on these basic concepts to embrace a multiplicity of services. (This line is 'out of place' as it does not refer to an element of telecommunications, but it serves to pinpoint the Data services.) TWX as we have seen is a low speed Data service; Data-Telex offers low-medium speeds, and Multicom and Broadband offer a wide range up to 50 kb/s, which is the highest subscriber terminal speed level we can expect for general use for many years, although direct computer to computer connections will have to operate at much higher speeds eventually. Multicom uses modified E5 crossbars and special line facilities. It is Data transmission in the telephone image and will disappear with the advent of a true digital system. Its usefulness will start to decline rapidly by 1977-79 if Canada moves vigorously into digital technology.

TELENET is a logical extension of message-record systems to employ computer technology to improve system efficiencies and to add to services offered to subscribers, as we have seen in 2.5.

FDM services are expected to peak in the late seventies when minimum cost hardware using LSI* will be available. During the seventies FDM-PCM combinations will appear. PCM which is a basic technique for digital transmission, is advancing rapidly in trunk route service. The measure of its advancement is the bit rate. Dates shown should be retarded 5 years for Canada. Rates in the thousands of megabits will be required before digital systems will become universal. 10^{12} b/s, the maximum rate shown, is generally accepted as possible although not before 1985 even in the U.S. ** Concurrently with PCM, digital switching will develop. Such switches will be all electronic but must not be confused with the new electronic switches now being brought forward by the telephone companies. These, although computer controlled, are designed to service voice systems. The Siemens EDS would appear to be a first generation digital switch. It has no multiplexing features but operates in a circuit switching mode to exchange digital signals between subscriber lines. This switch is a forerunner of the techniques required for simultaneous switching and multiplexing (PCM-TDM). Predictions on this latter subject are unreliable. It depends upon whether one is

* LSI - Large Scale Integrated circuits

** Will depend upon Laser systems (or equivalent) discussing what could be done or what will be done. To establish a universal digital system it will also be necessary to improve the subscriber loops from ordinary pairs of wires to balanced four wire and/or coax. This will be paced by the expansion rate of new voice plant and replacement of old. If the predicted growth rate of 12-15% holds, then in 15 years more new plant than old should exist, and this is marked as the start of "all digital services" in the U.S., assuming that country still to be the world leader.

Public switched color videophone would be practical over a digital network and until such a network with its megabit technology is available, we are inclined to link videophone to private systems only.

Portable telephone is expected to develop for some years as an extension of a subscribers local. A truly portable dial-in service being part of the public network awaits further technology developments.

Domestic satellite services commencing in the mid-seventies will make a contribution to the technology. Satellite transmission is favorable to digital techniques because of the relative freedom from burst noise interference common to ground communications systems. The nearly white noise background in satellite channels has led to important advances in digital channel coding techniques. Transmission of digitized video may be done advantageously, but in the case of Data, propagation time restricts answerback checking techniques.

The foregoing chronology of the advancement of the art of telecommunications is a consensus of opinion, with a preponderance of telephone industry inputs. Executives within the industry will confidently confirm that 1985 is an earliest practical date for widespread use of digital systems. The system inertia generated by telephone plant that was built to last, and the continuing demand for new voice services, both are pace setting factors which lend credence to the idea that changes will be long in coming. At this point then our forecast appears to be safe.

However, consider the following announcement in an industry wide press release of August 10, 1970:

> "A $7,000,000 system integration study program to ensure the compatibility of all elements in the (proposed) nation wide common carrier Data transmission network was launched last week by the Data Transmission Co-Datran"

Further details reveal that the studies will cover:

transcontinental microwave trunk system
computer controlled switching centers
local distribution systems

also the new techniques such as:

digital modulators for use with the trunking system
TDM (Time Division Multiplex)

and a test system.

Is this new system to be used in the second decade ahead? Not at all, millions of dollars are being gambled now by DATRAN, that starting at once they can have a large scale digital transmission system operating in this decade. The question is, can they do it?

10.3 The CN/CP Tel and TCTS Organizations

Before any final recommendations with regard to TWX-Telex and/or Data transmission in Canada can be made, certain basic assumptions as to the future status of the two principals must be stated. This is necessary because of the natures of the two organizations.

The CN/CP Tel organization operates on the basis of a signed agreement originating from the terms in certain sections of the Railway Act. This is a long term agreement and is one of long standing also. Nevertheless one must question the longevity of the agreement because it marries a crown corporation (CNR) which is dedicated to the public service, to a corporate giant (CPR) which is dedicated to the profit motive. For the association to continue it will be necessary for the Government to support its mandate to the CNR to stay in the communications field and for the CPR to continue to make a satisfactory profit. Neither of these conditions can be taken for granted.

The fact is, that Canada is standing on the threshold of a decade of heavy expenditures for Message-Record and Data transmission, involving multi-millions and perhaps billions of dollars for new plant and equipment in addition to the expansion plant which will be required for voice services. If the CN/CP Tel group wishes to commit to the new services, then the Government will have to decide how far it can go in providing financial support, in competition with the telephone monopoly group, (unless a non-competitive situation is developed for Data transmission). Furthermore if the new plant is to come under government regulation, as is likely, then the allowable profit must be such as to satisfy the CPR in order for the alliance to hold.

On the other hand the TCTS is a loose organization of telephone companies which has no charter, and no legal identity. The rules for membership are ill defined so that it is impossible to predict TCTS growth. The need for a change is real and a restructure is predictable although the timing may not be.

10.4 Considerations

10.4.1 Introduction - In this paper interconnection of TWX-Telex has been related to Data transmission but not to voice. The papers on Interconnection deal with all three as special cases of a single problem. An alternate view is that they are to such a limited extent that separate solutions can be found. Therefore at the risk of being accused of oversimplification by separating voice from the others the latter will be dealt with first.

10.4.2 Voice-Interconnection - The principal reason for the demand by CN/CP Tel for voice interconnection through the switched public network is that this would greatly increase their competitive position for the leasing of private circuits for voice. Consideration must be given also to the argument advanced by the CN/CP Tel to the effect that monopoly carries its own obligations and one of these is that the switched network services, which have been developed under the umbrella of monopoly, must be accessible to any buyer on favourable terms, even to a competitor. Two provinces, (ref page 101) may have set a legal precedent for the argument that once voice interconnection is established the resulting system is no longer private but public and therefore enters the general monopoly. Judicial consideration would probably lead to a solution of this problem.

10.4.3 Interconnection TWX-Telex - Interconnection, can be defined to be limited to interfacing of technology and services and not of management or corporate organizations. Interconnection pre-supposes that two technical systems exist and will continue to expand on their separate paths and with them the services and costs for interconnection will also increase.

We have seen that the ratio of Telex to TWX used for Message-Record services is 5:1 whereas in the U.S.A. it is closer to 1:1 and consequently there is much less possible business dislocation in Canada as a result. Noting also that this ratio is not likely to worsen in Canada as the TWX system is expected to develop as a Data transmission service, then it can be said that there is no pressure for interconnection of the two systems in Canada. Immediate needs can easily be met as TCTS have suggested by subscribers renting a second terminal. Lastly, all of the arguments against interconnection advanced by both competitors and as noted from the U.S. studies seem to us to be valid.

10.4.4 Integration of Services - Integration we define to include complete unification with one technical control and at least a unified managerial structure. It is only through integration that the following benefits can be obtained

1. Maximum Canadian commercial and sociological development. A dual, interconnected system restricts communications both within the country and with neighbouring nations.
2. Most economical integration with services in neighbouring countries because of unified long range planning with them.
3. Add to these weight of the arguments advanced by CN/CP Tel (7.4) which seem to be reasonable and cogent.

These arguments lead to the conclusion that some form of integrated service for Canada must be considered. If the earlier prognosis on developments of technology is at all correct, then Data transmission will be the central issue for integration.

The CN/CP Tel submission for a limited monopoly below 600 baud is not related to any time frame nor is any hint given as to how the resulting integrated system could or would expand ultimately to encompass the range of Data transmission foreseeable as a requirement in the next two decades. Thus there is no measure of the probable life of the proposed system. At the same time it is proposed that the private service Data market above 600 baud be developed competitively. Already between the Broadband Interchange and the Multicom system we have competing wide-range Data services not necessarily committed to identical technology. This means that in a matter of a few years a major interconnection problem could develop as the computing machinery of the business world will become less and less tolerant to incompatibilities between competing systems.

There is no way in which two mutually exclusive Data systems can be developed in Canada without giving rise within this decade to a serious interconnection problem as well as to duplications in plant and other costs. Also, it has not been established to what degree the CN/CP monopoly could be effective since it excludes private services which seems to offer a generous loophole.

10.4.5 Conclusion - We have shown that governments of our Western neighbours have made important decisions with regard to integration of services, and to data transmission technology. In similar areas Canada stands as yet undecided and uncommitted. At the least, more study and research into data transmission technology is indicated. This would require more active participation in the CCITT backed by more Government and industry research. Additionally, it is clear that it would be advantageous to Canada and to the U.S. if long term understandings with the FCC and also W.U. were entered into. These will be required for the coordinated development of Record-Message, Data services on this continent. Finally, the development of digital telecommunication technology for the advancement of data services in Canada in an efficient and logical manner, is a task of great magnitude and complexity. Therefore it is to be expected that the Government will assume a responsible role in this field in order to protect the public interest.

APPENDIX A

BLOCK DIAGRAMS FOR THE TELEX NETWORK

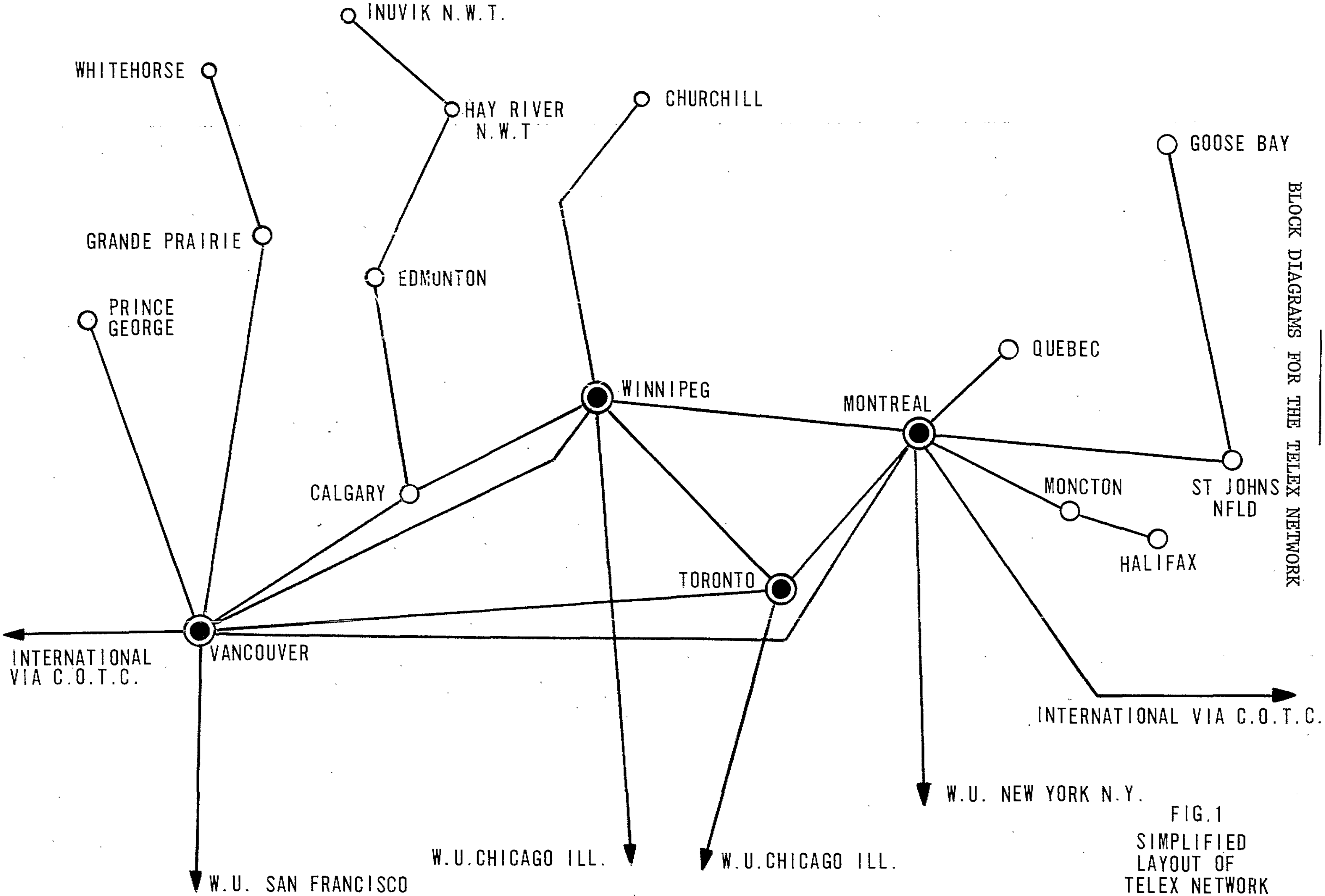


FIG.1
SIMPLIFIED LAYOUT OF TELEX NETWORK

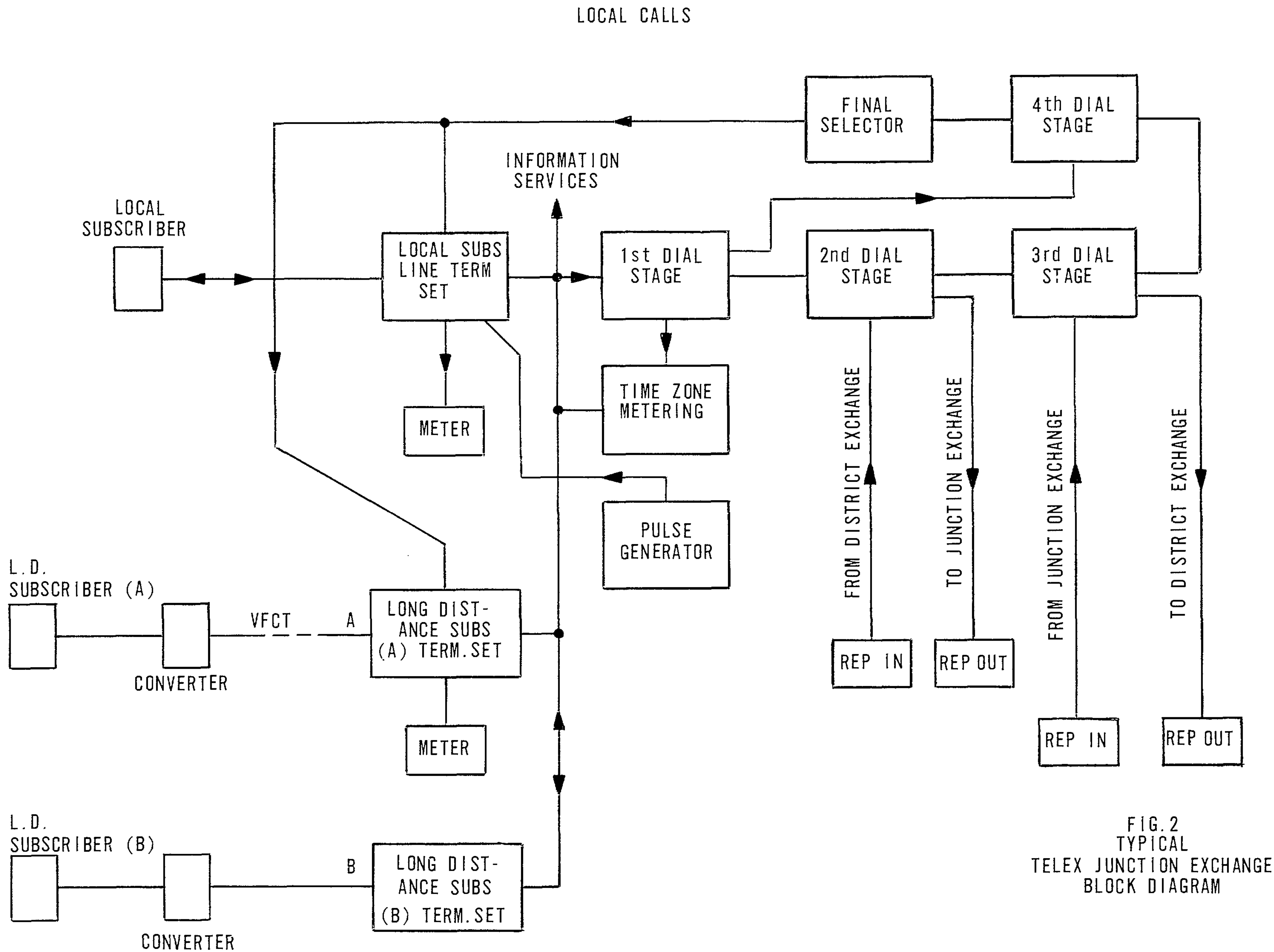


FIG.2
TYPICAL
TELEX JUNCTION EXCHANGE
BLOCK DIAGRAM

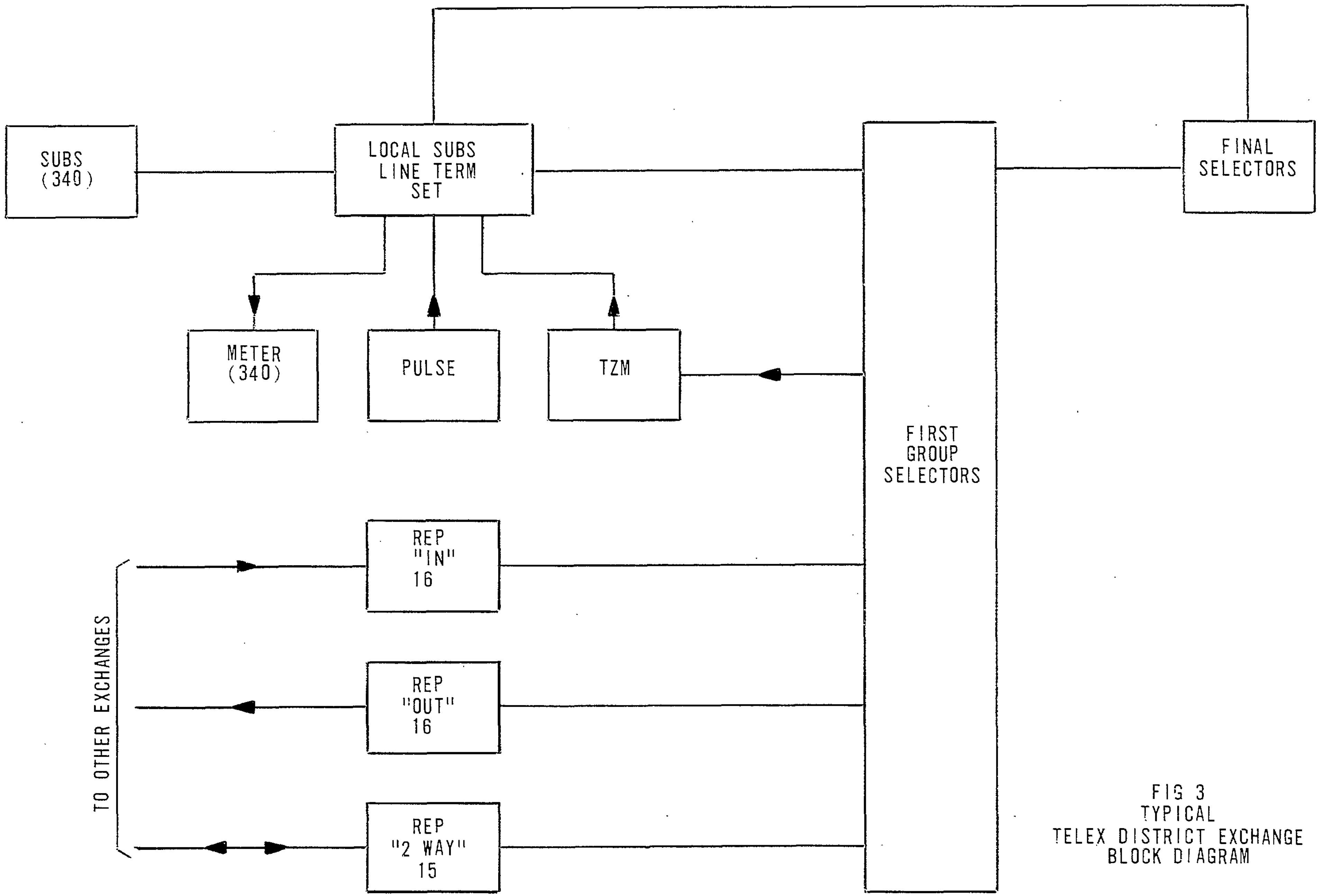


FIG 3
TYPICAL
TELEX DISTRICT EXCHANGE
BLOCK DIAGRAM

CONCENTRATOR LAYOUT

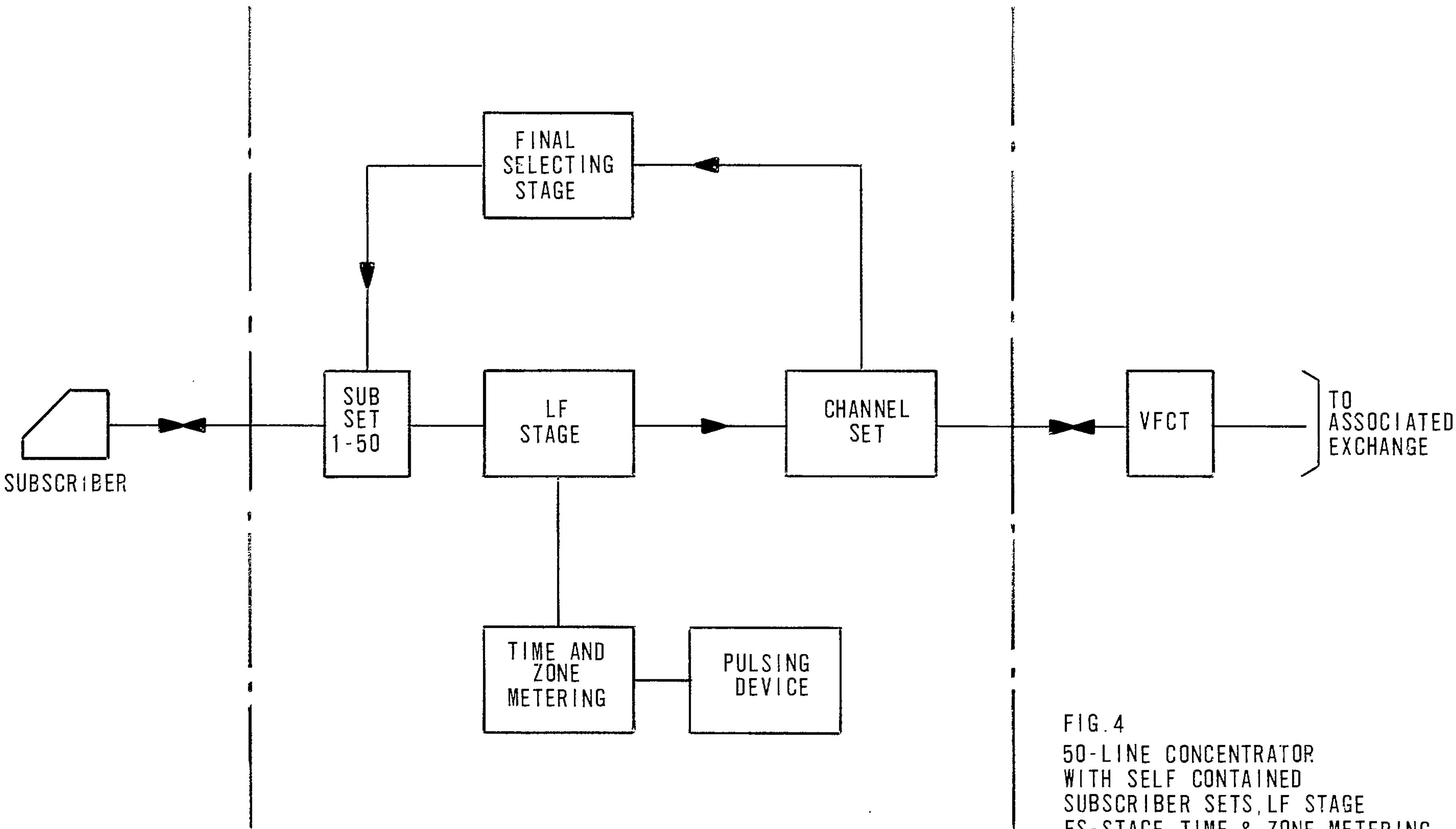


FIG.4
50-LINE CONCENTRATOR
WITH SELF CONTAINED
SUBSCRIBER SETS, LF STAGE
FS-STAGE, TIME & ZONE METERING
APPARATUS & CHANNEL TERM. SETS

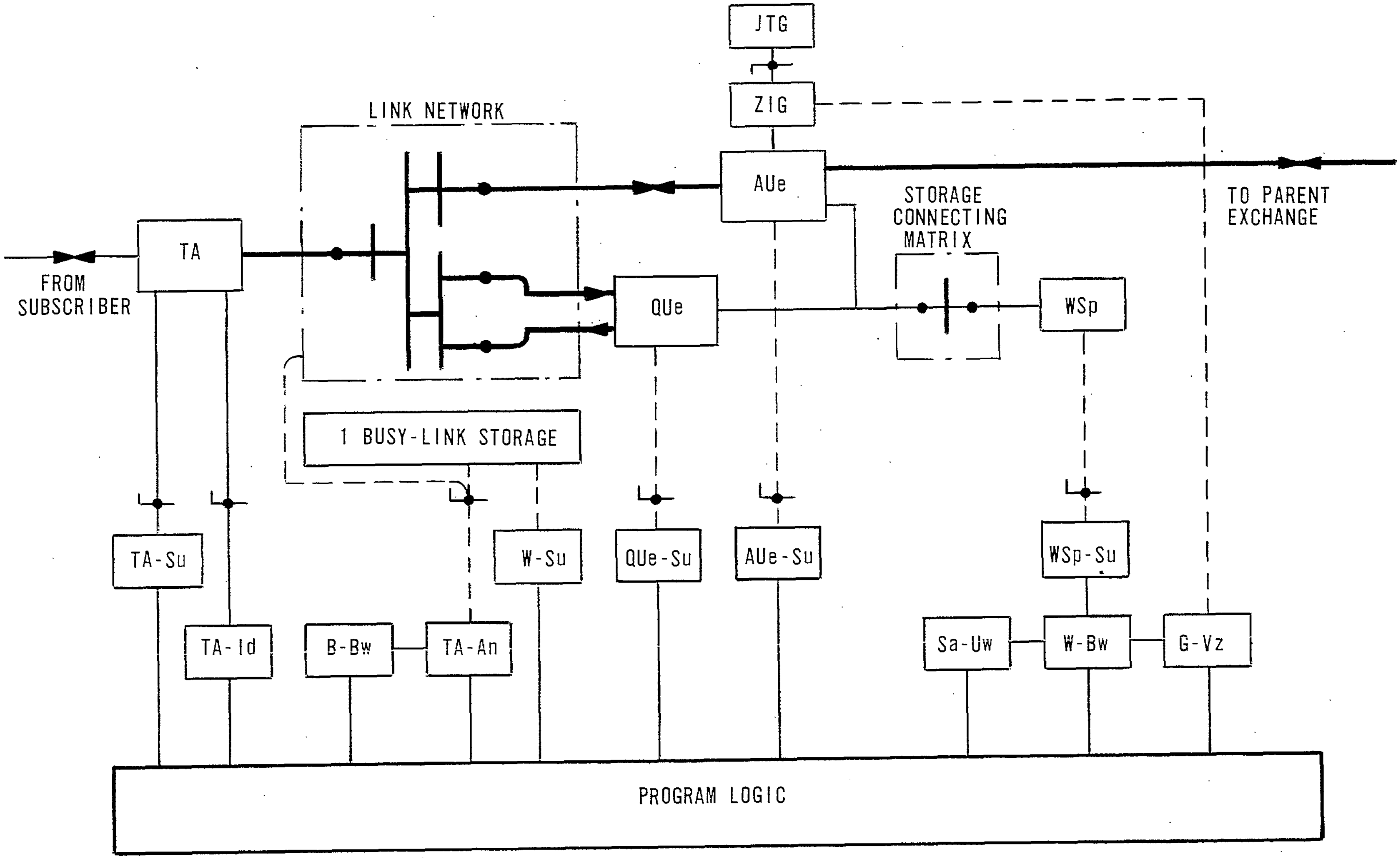
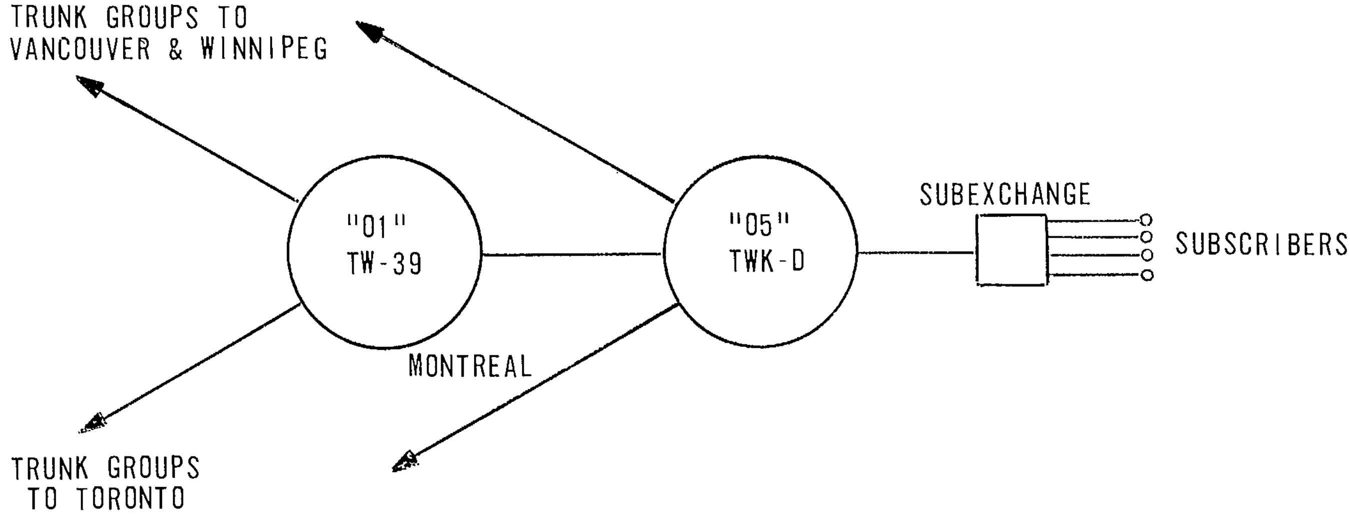


FIG.5
BLOCK DIAGRAM
OF TWK



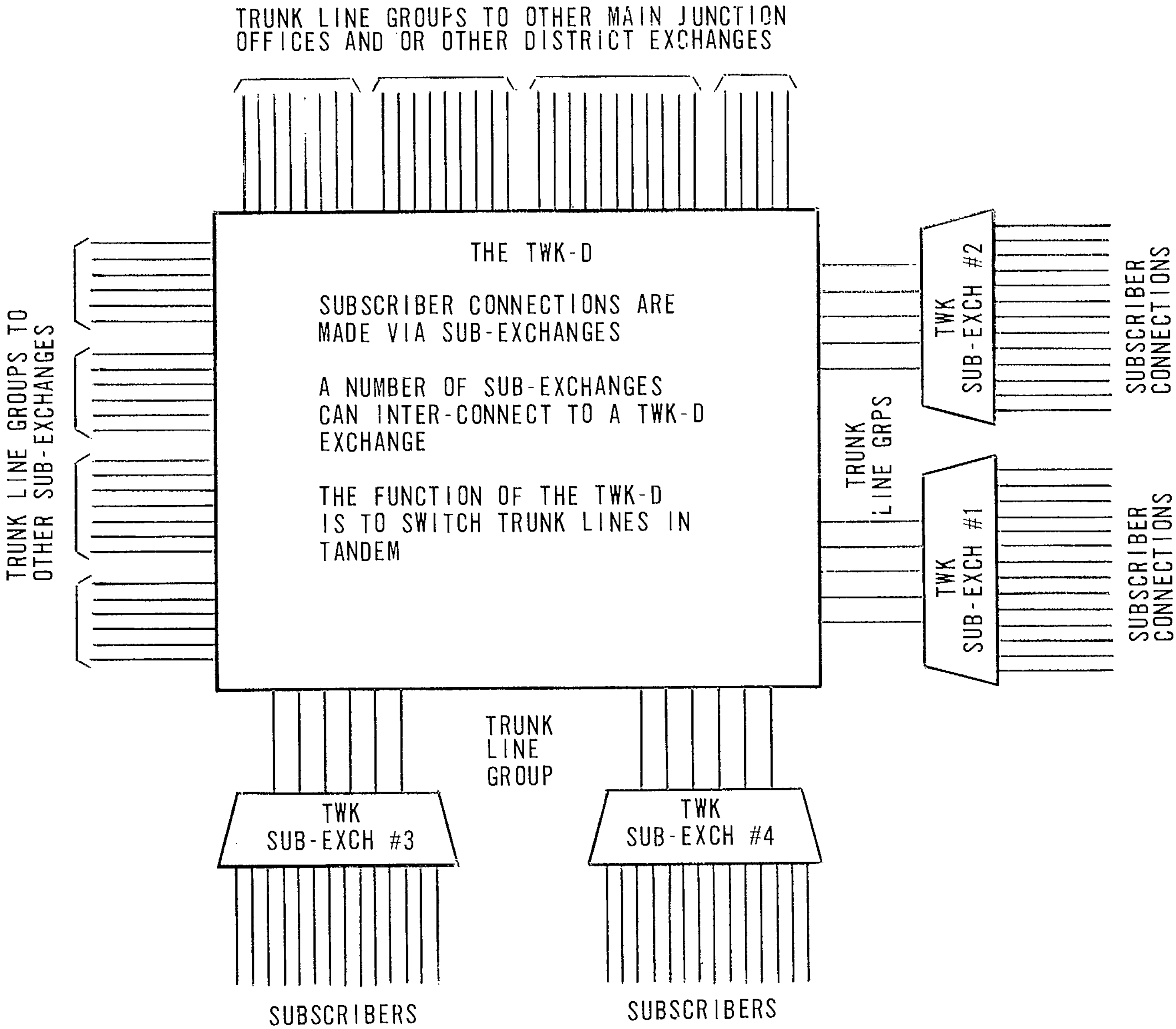


FIG 6
THE INCORPORATION
OF TWK-D EXCHANGE

CHANNEL SPACING

SPECTRUM	OPTION 1 170Hz CENTRE FREQUENCY Hz	OPTION 1 170Hz CHANNEL NUMBER	OPTION 2 340Hz CENTRE FREQUENCY Hz	OPTION 2 340Hz CHANNEL NUMBER	OPTION 3 240Hz CENTRE FREQUENCY Hz	OPTION 3 240Hz CHANNEL NUMBER	OPTION 4 SPECIAL CENTRE FREQUENCY Hz	OPTION 4 SPECIAL CHANNEL NUMBER	OPTION 5 SPECIAL CENTRE FREQUENCY Hz	OPTION 5 SPECIAL CHANNEL NUMBER
0.3-3.4 kHz	425	1	510	31	480	101				
	595	2	850	32	720	102				
	765	3	1190	33	960	103				
	935	4	1530	34	1200	104				
	1105	5	1870	35	1440	105				
	1275	6	2210	36	1680	106				
	1445	7	2550	37	1920	107				
	1615	8	2890	38	2160	108				
	1785	9	3230	39	2400	109				
	1955	10			2640	110				
	2125	11			2880	111				
	2295	12			3120	112				
	2465	13								
	2635	14								
	2805	15								
	2975	16								
	3145	17								
	3315	18								

SPECTRUM	OPTION 4 SPECIAL CENTRE FREQUENCY Hz	OPTION 4 SPECIAL CHANNEL NUMBER	OPTION 5 SPECIAL CENTRE FREQUENCY Hz	OPTION 5 SPECIAL CHANNEL NUMBER
3-5.2 kHz	3550	21	3650	41
	3750	22	4050	42
	3950	23	4470	43
	4150	24	4930	44
	4360	25		
	4580	26		
	4810	27		
	5050	28		

FIG. 7

APPENDIX B

Trans-Canada Telephone System

1 Nicholas Street, Room 500,
P.O. Box 462, Ottawa 2, Ont.
Telephone 613 239-5997
TWX 610 562-1941

N. C. Phemister
Assistant Chairman
and Secretary

July 29, 1970

Mr. G. Davidson
Department of Communications
Berger Building
100 Metcalfe Street
Ottawa 4, Ontario

Dear Mr. Davidson:

RE: Telecommission Study 8 (b) ii

We are submitting, herewith, papers on behalf of Trans-Canada Telephone System.

1. Paper on the Interconnection Between the Two Major Competing Common Carrier Organizations.

2. Paper on Technical Considerations of Interconnection.

Yours truly,

Assistant Chairman
and Secretary

LBS:gm

Enclosures

APPENDIX C

CP Telecommunications
Suite 418, Place du Canada, Montreal 101, Que.

C W Taylor
Chief Engineer

File - A1/SF/118-8(b)

Montreal, July 17, 1970.

Mr. G.K. Davidson,
Terrestrial Systems Consultant,
National Telecommunications Branch,
Department of Communications,
100 Metcalfe St.,
Ottawa 4, Ont.

Telecommission Study-8B(ii)

Dear Sir,

Enclosed herewith are four copies of Canadian National - Canadian Pacific Telecommunications submission in response to Telecommission Study - 8B (ii).

While the Profile of Work Program calls for a study of Interconnection of Telex -TWX circuits, our submission has been enlarged in accordance with your letter of March 10, 1970 to cover the broader issues of "Carrier to Carrier Interconnection".

We would appreciate your classifying this submission as confidential to the Telecommission pending your receipt of formal submissions from all interested parties. At that time we would be agreeable to an exchange of submissions with other parties if they so wish.

We would be pleased to meet with you at any time to review our position on interconnection, if questions arise which you would like to explore in greater depth.

Yours very truly,

C.W. Taylor

TEL. 866-8701
AREA 514 RÉGION

CANADIAN OVERSEAS TELECOMMUNICATION CORPORATION
LA SOCIÉTÉ CANADIENNE DES TÉLÉCOMMUNICATIONS TRANSMARINES

ENGINEERING AND OPERATIONS DEPARTMENT
DIVISION DU GÉNIE ET DES OPERATIONS

625 BELMONT STREET
MONTREAL 101

625 RUE BELMONT
MONTRÉAL 101

OUR REF.: NOTRE RÉF.: V1-1/3/70/JSC/ 686   YOUR REF.: VOTRE RÉF.:

MAY 21 1970

Mr. G.K. Davidson,
Terrestrial Systems Consultant,
National Telecommunications Branch,
Department of Communications,
100 Metcalfe Street,
Ottawa,
Ontario.

Dear Sir,

Telecommission Study 8b(iii)
Special Studies - Interconnection of Terminal Devices

This refers to the questions listed in your telex of May 15th 1970 and confirms replies provided during telephone discussion between Messrs. Davidson/Crispin on May 19th 1970.

QUESTION 1 What is the predicted life of the COTC special Telex/TWX code conversion equipment?

ANSWER 1 The equipment is considered to be highly reliable and a total life of 25 years would be a reasonable estimate. However, COTC will be replacing this equipment with its new computer controlled telex centre which goes into operation in the last quarter of 1970.

QUESTION 2 Is COTC making plans to expand its capacity and if so, have you budget figures for installed costs?

ANSWER 2 No, as implied above no further special conversion equipment will be purchased. The original conversion equipment was approximately $20,000 per unit but this cost is somewhat out of date.

QUESTION 3 If the conversion services were no longer required what impact would this have on the COTC operations in terms of operating costs and personnel.

ANSWER 3 The operating costs and personnel may be considered under two headings :-

3.1 Equipment Maintenance Costs

3.2 Operator Assistance costs

...2

3.1 The COTC costs for equipment maintenance have been very low and if there is a telex or TWX switching centre proximate then costs of less than one-half a man would be allocated to the TWX/telex converter maintenance.

3.2 Regarding the operator assistance costs, these have also been low, however, the important point is probably that when a new system is introduced, it is considered desirable to provide special assistance operators for the convenience of the subscribers and in the COTC case, for enquiries from overseas administrations. Assistance operating positions for TWX/telex would desirably have special features related to this conversion, but the amount of assistance would probably be no more than that required within say, the present Canadian telex service when the new system has settled down.

We trust that this information is sufficient for your needs and we will, of course, be pleased to answer any further enquiries.

Yours very truly,

J.S. Crispin

J. S. Crispin, Chief Engineer, Engineering

RL.

APPENDIX E

TRANS-CANADA TELEPHONE SYSTEM

Issue 3
20 Jul 70

Technical Considerations of Interconnection

CONTENTS

Section 1

Introduction

The purpose of this paper is to provide some technical background for discussion of interconnection of the public address switched network and private lines provided by the telecommunications common carriers, with

(a) privately owned systems,

(b) other carriers facilities, and

(c) privately owned terminals.

One of the main objectives of the Trans-Canada Telephone System is to protect and improve the Telecommunication environment for all users. The present network has evolved over a period of 90 years from very crude beginnings to its present reliable and capable status. The repetitive cycle of research followed by development, followed by experience, followed by research etc. is the process which has led to this situation. The present design characteristics of the network are based on the probability of a variety of things either happening or not happening and this probability is based in turn on a great deal of experience. The design of the Telecommunications network is, in reality, an economic balance between the risk of certain known or recognized things happening and the necessary controls which prevent untoward things from happening - obviously a balance between risk and control must be experience rated, i.e. based on past experience or "probability" even though modern computor techniques provide a good initial design basis. Taking risk which is not experience rated can lead to serious service disruption and the obvious economic consequences. The Trans-Canada Telephone System operates on the basis of experience rated or "known" risk.

The basic technical problem of interconnecting things to the Trans-Canada Telephone System's telecommunication network is to adequately control the risk of polluting the network with signals, systems, or procedures which will interfere with other users or degrade the services offered. The risks must be carefully evaluated along with the attendant economic penalties.

Danger to the system and its users from interconnection, whether physical or otherwise, is not experience rated simply because sufficient time has not elapsed to gather this experience. It is just as undesirable to permit connection of anything and everything, willy-nilly, to the network, as has been shown in Europe and Asia (where PTT's have been obliged to impose strict controls on connection of customer owned terminals and systems), as it is to prevent connection for logical and reasonable uses. One of the biggest difficulties in interconnection is that of identifying sources of trouble, first to identify that a trouble exists before it affects other users, and then to identify what has caused the problem and what must be done to solve it.

In essence we are considering risk and how to control it. By taking careful and deliberate action now and avoiding precipitate decisions (which could result from pressure from manufacturers or customers), experience gained will show the direction to follow without producing any catastrophic effects.

The following sections outline the characteristics of the Canadian Telecommunication System and some of the characteristics which must be given priority consideration in any discussion of interconnection.

In these sections "private lines" refers to leased transmission facilities dedicated to, and designed for a specific customer by the Canadian Telecommunications companies and which does not interconnect with the public address switched network.

Section 2

A) Canadian Telecommunication System Description

The simplest form of a communicating system consists of two terminals connected together by a pair of wires. (A terminal is here understood to be the point at which information enters or leaves a communicating system). Although there are many such systems in use (public address, intercommunication, etc.) they are all of a very local nature and do not form part of, or make use of any more extensive systems.

The Canadian Telecommunication System in which we are interested is much more complex. Figure 1 is the classical and familiar picture showing the typical make-up of the system. The differences between switched network and private line facilities are that the switched network is an "anywhere-to-anywhere" system switching on demand while private lines are specially engineered between specific points, to meet agreed parameters, and covered by individual contract. Both types of services are carried over common transmission routes or systems.

If we temporarily ignore the private line facilities, Figure 1 can be used to illustrate how the toll (long distance) switching plan operates. In the present toll switching plan there are five ranks or classes of switching centres. The highest rank is the Regional Centre. The lowest rank, called the End Office, is the telephone exchange in which the subscriber's loops terminate. The order of route choice at each control centre is indicated in Figure 1 by the numbers in parentheses. In the example there are ten possible routes for the call, only one of which requires the maximum of seven intermediate links. (The number of links refers to the number of toll trunks or circuits in tandem or end-to-end from toll centre to toll centre). Note that the first choice route involves two intermediate links. In many cases, a single link exists between the two toll centres and this would be the first choice route.

The probability that a call will require more than N links in tandem to reach its destination decreases rapidly as N increases from two to seven. First, a large majority of toll calls are between end offices associated with the same Regional Centre. The final routes in these cases will not extend as far as the Regional Centre, and may not involve even the next lower ranking centres in the chain. The maximum number of toll trunks in these connections is, therefore, less than seven. Secondly, even a call between telephones associated with different Regional Centres is routed over the maximum of seven intermediate toll links only when all of the normally available high usage trunk groups are busy. The probability of this happening in the case illustrated in Figure 1 is only P^5, where P is the probability that all trunks in any one high usage group are busy (there are five high usage groups shown in dashed lines in the figure). Thirdly, many calls do not originate all the way down the line since each class of office has all the duties (in its area) of all lower classes.

Table 1 clarifies these points. The middle column of this table shows, for the fictitious system of Figure 1, the probability that the completion of a toll call will require N or more links between toll centres, for value of N from 1 to 7. In computing these probabilities the assumptions that we used in this instance are: that the chance that all trunks in any one high usage group are simultaneously busy is 0.1; that the solid line routes are always available; and that, of the available routes, we always select the one with the fewest links. The figures in Table 1 illustrate how increasingly unlikely are the connections requiring more and more links. These numbers are, of course, highly idealized and simplified. Actual figures from a survey are shown in the last column of Table 1. Note that 80% of calls were completed over only one intermediate link (this is not possible in the system shown in Figure 1, which does not show a direct trunk between toll centres) and that as many as seven intermediate links were required in only 3 out of 100,000 calls. It is experience with probability information such as that just described which has permitted the TCT System to strike an economic balance between the risk of a user being unable to make a call because all circuits are busy and the cost of providing sufficient circuits and equipment such that no one would ever encounter a condition of all circuits busy. (The situation where the called party is busy is a separate one to that where all circuits are busy).

It is apparent that the switching pattern that has been described imposes strict transmission requirements on toll trunks. Up to seven toll trunks may be connected in tandem, and successive calls between the same two telephones may take different routes and encounter different numbers and kinds of circuits. The loss must not be excessive when calls are routed over the maximum number of links, and there should not be too great a variation in the transmission quality afforded over the different possible routes that a call might take. Loss cannot be permitted to get too low either or echo, singing, crosstalk, and noise can cause excessive transmission impairment. In the days when circuits were controlled manually on a manual link patching basis by operators, maintenance was carried out on a "call out" basis where a defective circuit would be identified and repaired. The same economic requirements and technological changes that have led to automatic switching of long distance circuits have also required that maintenance must now be carried out on a routine basis and the design of the switching apparatus, the maintenance test equipment, and the maintenance procedures have all changed to accommodate this. As economics and technology continue to change in the future, so will the methods of design and maintenance, on a carefully planned basis and timetable.

Figure 2 shows in more detail the circuit make-up of a typical terminal to terminal connection. Here again the difference between switched network and private line facilities is that the private line by-passes the switching equipment and is custom designed. A connection may involve transmission between terminals through a single central office, or through a number of links including several offices, cable facilities and carrier systems. The terminal located on the subscriber's premises generates or receives the information to be transmitted, generates supervisory signals to indicate to the local central office the status of the terminal, and generates the signalling information to indicate to the switching system what connections are to be made and to initiate charging. The local central office must, of course, correctly interpret the information it obtains from the terminal and pass on to the toll centre the information necessary for the latter to carry out its tasks. The toll centre must in turn perform functions based on the information it receives from the local central office and so forth.

It is easy to see that each entity in the chain between terminals, including the terminals, must complement all other entities if the system is to operate properly. Years of experience in many fields has permitted the Trans-Canada Telephone System to allot to each portion or entity of the overall system appropriate transmission parameters and limits, based on the theory of probability and considering the economics of risk versus control which permits these portions to work together to provide the desired end-to-end transmission quality and behaviour. It should be apparent at this point that a malfunction anywhere in this chain can make itself felt over a considerable distance.

The toll trunk in Figure 2 is called a four-wire system since the signals in opposite directions go on separate paths. These facilities are usually microwave radio or cable carrying a number of trunk circuits or channels by means of carrier multiplexing in which individual voice grade channels are combined for economical transmission. A much more complete treatment of frequency division multiplexing can be found in Chapter 5 of Reference 1.

Inherent in any transmission system are small amounts of residual imperfections (i.e. non-linearities, envelope delay distortion, etc.). These imperfections generate intermodulation distortion which causes some intermixing of the individual channel signals that make up the multiplex signal. The effects of this intermodulation distortion become more pronounced as the signal power (load) applied to the system is increased, and result in an increase in the noise level within individual channels. This noise can take the form of intelligible crosstalk if the high level signals have strong single frequency components.

Thermal noise (hiss) exists in addition to the noise generated by intermodulation distortion. This thermal noise is generated in the electronic circuitry which makes up the system and is independent of system load whereas the intermodulation noise increases rapidly with increasing signal power.

In developing a transmission system the designer is faced with striking a balance among (a) required load carrying capacity, (b) thermal noise, (c) intermodulation noise and (d) cost. (See Chapters 7, 10 and 12 of Reference 1). In general, the transmission system is designed to have the lowest possible cost while meeting the required load carrying capacity and noise objectives. Greater load capacity or better noise objectives result in more expensive systems.

In most system designs the signal to noise ratio is an important operating parameter. To achieve the optimum signal to noise performance it is desirable to select an operating point for this system at which thermal noise and intermodulation noise are appropriately balanced. Figure 3 illustrates the relationship among signal power, thermal noise power, and intermodulation noise power as a function of the input signal power. As the input signal increases from a low power level the signal-to-noise ratio gradually increases to a point at which the optimum signal-to-noise ratio is reached. Beyond this point the intermodulation noise increases more rapidly than the output signal power. As a result the overall signal to noise ratio tends to decrease.

From this figure, as one would expect, if the input signal exceeds those for which the system was designed increased noise would be encountered. However, the intermodulation noise increases at a far faster rate and Figure 4 shows how the probability increases rapidly that energy in one channel will appear as intelligible energy in another channel (crosstalk). This is one of the most serious forms of overload in that the crosstalk will not appear in the channel that is doing the overloading but rather its results will appear in other channels. It is insidious in that a strong signal in channel A can cause the information in channel B to appear in channel C unknown to the users of either channel A or B. On the other hand if the signal energy in channel A is maintained at or below the design maximum for the system, intelligible crosstalk is very unlikely to occur. Situations of the type just described can conceivably occur at any point in the system outlined in Figure 2 but the results may be detected only thousands of miles away. This discussion points out the necessity for each entity of the system to be designed and maintained as part of, and complementary to the overall system.

Terminal Characteristics

In order to design any system, characteristics of the terminal must be established. The major terminal on the voice portion of the system is the telephone. It is designed to interface with the human head for the exchange of information. Many subjective assessments of various aspects of telephone transmission quality have been made to determine what is poor, fair, good and excellent from the point of view of the user. Figure 5 is an example of such a subjective appraisal, this one concerned with the noise received by the terminal from the system. Knowledgeable interpretation of this information permits a maintenance level of acceptable noise to be chosen which is both satisfactory to the user and economical to the system.

Similar subjective appraisals, using a large number of subjects, have produced information indicating the acceptable volume level and its range of acceptable values in received signals and also the levels of signals to be expected at the central office from the customer's location.

Using such information the many entities of Figure 2 have been designed and upgraded through the years to provide good end-to-end communication. (Reference 2 is a classic example of this type of information which is still a standard reference for the design of carrier systems).

Based upon the distribution of talker volumes and the characteristics of modern telephones, long haul microwave and cable carrier systems currently in use are designed to meet noise objectives and to provide the optimum signal to noise performance with a 4 KHz channel load of -16 dBm0 long term average power (dBm0 means dBm at the 0 Transmission Level Point). This long term average power level has also been adopted as the objective for future designs of long haul frequency division multiplex carrier systems.

The -16 dBm0 load is the maximum average load power for a voiceband channel that can be tolerated without incurring a noise penalty if every channel were used for transmission simultaneously in both directions. However, most users do not use both directions of transmission at the same time and not all channels are active at the same time. It is, therefore, required to convert the long term objective per channel for the system to an acceptable limit for an individual user's signal power. Experience shows that the average percentage of time a channel is switched into a connection during a busy hour for long haul carrier systems is about 70% ($10 \log 100/70 = 1.5$ dB) while a factor for transmission in one direction at a time is 0.5 ($10 \log 1/0.5 = 3$ dB). Using these factors, the operating signal level permitted at the 0 Transmission Level Point is calculated as follows:

Full Duplex

Long Term Load Objective	-16 dBm0
Adjustment for 70% usage	+1.5 dB
Permissible Load per Channel	-14.5 dBm0

Half Duplex

Long Term Load Objective	-16 dBm0
Adjustment for 70% usage	+1.5 dB
One-way Transmission	+3 dB
Permissible Load per Channel	-11.5 dBm0

To accommodate the mix between full and half duplex services and also to control intelligible crosstalk caused by high level tones, a compromise of -13 dBm0 has been adopted. Since there is normally a 1 dB loss between the central office switching equipment and 0 Transmission Level Point an average power level of -12 dBm0 was adopted for general application. These levels, of course, apply to energy within the normal voiceband of 300 to 3,000 Hertz. Energy at higher frequencies must be appropriately reduced in power in order not to cause interference to carrier and signalling systems used in various parts of the entities outlined in Figure 2.

Figure 6 shows how the maximum acceptable signal level from the terminal decreases as the frequency is increased and takes into account the potentially disruptive effect this could have. These are current standards and, of course, will be changed as technology and usage require.

Transmission of data signals (from business machines) is also carried out readily on the Public Address Network and over Private Line Facilities. Here a data set becomes part of the terminal to convert the digital signals to and from signals compatible with the Telecommunication System. The data capabilities of the Public Network have been carefully investigated (see Reference 13) and equipment developed to offer a variety of services.

The future trends in network design will, as in the past, be a result of the research-development-experience cycle. Just as a major improvement in design of the telephone instrument (see Reference 6) permitted major improvements in transmission quality and economics (a saving to date of $6 M in Bell Canada alone for copper and an estimated savings of 10 times this amount in capital cost and administrative expense), so will the application of semi-conductors (see Reference 5) and pulse transmission systems (see References 3 and 4). These new technologies are being applied today as their degree of risk becomes predictable through experience.

The development of the new telephone set permitted longer and more economical subscriber loops to be used. Continued improvement along these lines is anticipated such as replacing the present 20 Hz high voltage ringing signal with a tone signal, the ultimate replacement of dial pulse with Touch-Tone signalling, and a number of other changes in the terminal-to-central office area which will result in even longer and more economical loops. Techniques are presently available which with appropriate development can be used to provide distributed switching of subscriber's loops remote from the central office. Telephone wire and cable is not restricted to handling voice-band signals (if this was the case carrier systems could not operate over these cables). Carrying services into the home which require wider than voiceband capabilities, such as picturephone, yesterday was a dream, today is possible and tomorrow will be practical, and in fact will be necessary as the trend develops from an employee spending his working day at his office to spending his working day carrying out his work in his home. Terminals to allow him to communicate with his fellow employees, his supervision and his other contacts can be built today, will be built tomorrow, and the signalling and the supervisory requirements for interaction between the terminal and the communicating system will, of necessity, change. These changes must be brought about in a planned and controlled manner if chaos is to be avoided.

B) <u>Characteristics of TCTS Local (Exchange) Plant</u>

Figure 2 illustrated the various parts of the terminal system. As was pointed, out the design of each of the entities which make up this system are very much interrelated. It is proposed now to take a closer look at the loops which inter-connect the terminal with the local central office. Loops are generally provided by means of pairs of wires grouped together into cables. As one would expect the physical and electrical characteristics of the loop plant have a considerable effect on signalling and supervision, as well as on the safety of personnel. These characteristics will be considered briefly.

<u>Signal Characteristics</u>

The manner in which the local telephone plant is arranged and installed has been developed over a long period of time using experience gained to develop better methods and provide economically a suitably low risk from service interruption or deterioration. This arrangement meets the objectives of (1) protection to prevent hazard to life and property; (2) transmission capability required to permit the faithful transmission of the desired information and in addition of the necessary signals and supervision; (3) appropriate design to minimize interference between telephone circuits and from power systems; (4) flexibility (i.e. the ability to provide services rapidly anywhere in the area served); and (5) a reasonable cost.

The subscriber Loop

Figure 7 shows a simplified sketch of the loop network covering a typical service area. All circuits intended to serve a particular part of the service area leave the central office in a large feeder cable, in this case consisting of 2700 pairs. In the central office the feeder cable is connected to the main distributing frame by means of other cables and from here, as the name implies, distributed to terminals on the switching equipment.

As service to the area requires the feeder cable is connected or spliced to other smaller cables, called distribution cables which may well be further divided into smaller cables at splice points until the cable terminal is reached at which point the drop connects a pair (or pairs) to the station protector at the customer's premises.

It is obvious from Figure 7 that telecommunication craftsmen have access to the pairs of wires at many places along the routes at different points in time. From time to time the routes change and the points at which cables join and the size of cables are changed to allow for growth and modification. There are an average of about 10 splice or access points on each telephone loop and the average loop is re-arranged at some point about once every two years.

Electrical Characteristics

The electrical characteristics of the loop plant may be divided into two groups, viz. (i) Those which are concerned with transmission over the loop such as attenuation, bandwidth, impedance, etc. and (ii) those relating to cable balance, i.e. inter-action between loops within a cable or with other elements of the surroundings (crosstalk, electrical induction, etc.)

Characteristics in the first group control quality of transmission performance and signalling. The design installation and maintenance practices of the TCTS, which have been developed over many years' experience, coupled with careful design and construction on the part of the cable manufacturer control these characteristics to the degree dictated by reasonable risk and cost. Characteristics in the second group, if not carefully controlled can cause undesired crosstalk between pairs in the cable as well as being induced with undesired potentials when exposed to the inductive fields from power distribution systems.

(i) Transmission Characteristics

The subscriber loop function is to carry information backwards and forwards between the terminal and the central office. It presents resistance to the passage of DC currents, attenuates or reduces alternating current energy (voice signals for example), and, if improperly designed or used, can produce crosstalk. (See next section, Cable Balance)

Loops normally consist of pairs of copper wires arranged in cables (Bell Canada alone has 4,000,000 working loops). They vary widely in length and size (gauge) of wire used, and are the most expensive single investment directly associated with a particular subscriber's service. Typically, in Bell Canada, the average investment for a 10,000 foot loop is $200, for a 20,000 loop is more than double at $500, and 90% of all loops are 20,000 feet long or less. (The cost of adding to, or renewing existing plant is considerably higher - typically $350 for a 10,000 foot loop for example). In some areas of Canada local conditions such as low population density and long distances result in considerably greater loop complexity and cost.

Since the cost of an installed telephone including wiring is about $60 and the cost of the directly associated equipment in the central office excluding switching equipment is between $36 and $60, the telecommunication industry expends a great deal of effort to reduce the cost of loops. One logical means of cost reduction is to use less material and this is done by using finer gauge cables. Much new plant uses 26 gauge wires as compared to the earlier heavier gauges but thinner wire increases the resistance and attenuation for a given length and this must be compensated by changes in the terminal and/or central office in order to maintain the over all transmission quality and control.

The electrical characteristics of loops also vary widely. In Bell Canada the loops have a mean DC resistance of about 500 ohms and a standard deviation of about 400 ohms. It has a mean 1 KHz insertion loss of 3.3 dB with a standard deviation of 2 dB and at 3 KHz a mean insertion loss of 7.4 dB with a standard deviation of 4.2 dB. These variations must be accommodated in the design of signalling, supervision, and transmission objectives for the overall system.

A series of improvements over the years has permitted economies in provision of service and improvements in quality. For example early telephones were quite inefficient and quite insensitive and required batteries at each location. The wire used to connect these stations to the central office was large and, by today's standards, would be quite impossible to provide because of cost and space considerations. The 300 type set offered a total improvement of 15 dB (the sum of the improvements in transmitter and receiver efficiency) over earlier sets. The 500 type set (see reference 6) offered an improvement over the 300 type set of a further 7.5 dB. These two sets together have therefore provided an improvement in excess of 20 dB in efficiency, and 20 dB is equivalent to an increase in sound intensity of 100 times. The 500 type set in addition is designed to partially compensate for the increase of loop loss with distance from the central office. It is changes such as these which have permitted use of the fine gauge cables with their resulting economies.

(ii) Cable Pair Balance

The coupling of energy among pairs of a multipair cable and the coupling of energy from outside sources into the pairs must be controlled so that individual pairs may be usable as separate transmission channels.

This control is achieved by - limiting signals or noise power
- maintaining coupling to noise and signal sources
- reducing the susceptiveness to noise and other signals.

The signal or noise power is controlled by suitable design of terminals, central office equipment, and external energy sources. Coupling is controlled by balancing mutual impedance between the undesired energy source and each side of the affected circuit. Susceptiveness is controlled by longitudinally balancing the self impedances (series, shunt and switching) of each side of the affected circuit.

Energy is coupled to cable pairs from outside sources primarily through mutual inductances. Energy is coupled among cable pairs primarily through mutual capacitances. This coupled energy becomes distrubing only if the longitudinal balance of the self impedances is inadequate

Figure 8 shows (schematically) two wire pairs of a multipair cable, designated Pair A and Pair B. Typically, for cables used for loops, the capacitance between the two conductors of a pair (designated, conductor T and conductor R) is about .085 microfarad per mile. Each conductor of a pair also has an equivalent capacitance to ground of about .09 microfarad per mile. In addition, each conductor of a pair has a capacitance to each conductor of other adjacent pairs of approximately .007 microfarads per mile.

The direct paths by which energy is coupled between pairs are the interpair capacitances, C1, C2, C3, and C4 on Figure 8.

In order to explain the crosstalk mechanism, a voltage generator, e_B, is shown connected to Pair B. Setting aside, for the moment, the effects of the wire-to-ground capacitances, C5, C6, C7, and C8, we can assume that the voltage-to-ground of the T conductor of Pair B, e_{TB}, is equal in magnitude but opposite in polarity to voltage e_{RB}. If C1 equals C2, then the voltage coupled to the T conductor of Pair A from T of B through C1 would exactly cancel the voltage coupled from R of B through C2. Similarly, the voltages coupled to the R conductor of Pair A through capacitors C3 and C4 would also cancel. Hence, no net metallic voltage would be developed on either the T or R conductors of Pair A. That is, although there would be a non-interfering longitudinal voltage, there would no interfering metallic voltage directly coupled to Pair A. Then, as long as the self-impedances of Pair A are balanced, there would be no conversion of the coupled longitudinal voltage to metallic voltage. These pair-to-pair capacitances are controlled quite carefully in manufacture and the difference among the capacitances associated with any two pairs (or as it is called, the pair-to-pair capacitive imbalance) is typically less than .0001 microfarads per mile. In fact, for purposes of explaining crosstalk coupling, this pair-to-pair imbalance may be neglected.

The capacitance of the wires to ground, however, is not as closely controlled in manufacture. Hence C7 does not equal C8 and e_{TB} and e_{RB} to the conductors of Pair A are not completely cancelled, and a net voltage is induced in Pair A. (Similarly differences between C5 and C6 also cause a voltage to be induced in Pair A.)

As it turns out, the factors that control crosstalk between any two pairs in a cable are: (1) the magnitude of the interpair capacitance, C1, C2, C3, and C4, which is a function of the proximity of the two pairs within the cable; (2) the degree of imbalance (or difference) among them; and (3) the degree of balance (or matching of series impedance and impedance to ground) of the individual pairs, which is determined partly by C5-C6 and C7-C8. This last condition determines the degree of balance.

Longitudinal Balance is defined as the ratio of the disturbing longitudinal voltage (V_s) to the resulting metallic voltage (V_m) expressed in decibels as measured at the terminal (s) of the network under test:

$$\text{Longitudinal Balance} = 20 \log \left| \frac{Vs}{Vm} \right| \text{ dB.}$$

(see Ref 14).

The degree of longitudinal balance in cables is controlled by design so that the crosstalk coupling loss between pairs is generally well over 100 dB with about one percent of pairs having coupling losses of 80 dB or less at 1000 Hz. Since this coupling is primarily capacitive, the coupling loss will decrease (hence crosstalk will increase) with increasing frequency at the rate of 6 dB each time the frequency is doubled. However, to achieve these levels of crosstalk loss, it is necessary that the balance to ground at the terminations of the pairs also be controlled. Tests have shown that if one conductor of both pairs is grounded, crosstalk will be increased by as much as 60 dB.

Central office circuits and terminal equipment and wiring provided by the TCTS are carefully designed, installed, and maintained to insure a high degree of balance to ground. However, equipment, even when suitably designed and manufactured, can be unbalanced to ground through improper installation.

Hence, one important factor in preventing interference to other customers through crosstalk is to insure that the line terminations in the terminal ARE balanced to ground.

Section 3

A) Safety

In the Telecommunication industry protection of customers, personnel, and plant from hazardous voltages has always been a prime consideration in design of the many entities of the system. When interconnection with plant owned by others is considered, the protection of personnel and plant from hazardous voltages induced from outside is of even greater significance since the Telecommunications supplier has little or no control over the design or condition of the interconnected plant.

Two factors are important to an understanding of the need for hazardous voltage protection. These are (1) the effects of electric shock on human beings and (2) the extent to which telecommunications personnel may be exposed to such shock.

(a) Effects of Electric Shock

The harmful effects of electric shock are determined, basically, by the amount of current passing through the human body. The amount of current that will flow through the body, in turn, depends on several factors: the voltage on the electric conductor to which the body is exposed, the source impedance of the voltage, and the highly variable body resistance. Body resistance consists of skin, or contact, resistance and internal body resistance. While the internal resistance of the body has a relatively fixed value of 300 to 500 ohms, skin or contact resistance can vary from 500 ohms to several hundred thousand ohms, depending on a number of conditions. Perspiration, wet electrodes, sharp electrodes such as a nail in a shoe, or puncture of the skin can result in much lower resistance.

In evaluating the shock hazards to the average craftsman in the TCT System, we have assumed total body resistance of 1500 ohms. This value is in line with the resistance value utilized by safety experts in other fields.

The actual path of current through the body is important in determining the extent of damage caused by electric current. Fatalities nearly always involve a path through the heart, but in practical safety considerations the particular path through the body cannot be assumed or taken into account. The following table describes the effects of 60 Hz alternating current on the human body:

AC Current (RMS)	Effect
1 ma	Perception threshold
5 ma or more	Painful shocks
10 ma or more	Local muscular contraction sufficient to cause freezing to the circuit for 2.5% of the population.
15 ma or more	Freezing for 50% of the population.
30 ma or more	Breathing difficult, possible unconsciousness
50 ma to 100 ma	Possibly fatal
100 ma or more	Generally fatal

The duration of the current flow is, of course, important. The values of current listed above, in the fatal range, need not have a duration over one second to be fatal. Tests on animals show that tolerance increases as shock duration decreases (see Refs 7 & 8).

While current is the parameter that determines the severity of shock, the voltage on an exposed conducting part is the only criterion that is practical for use in arriving at limits or guidelines for the protection of personnel. By translating the above current values, by means of expected body resistance, the industry has established longstanding limits on allowable voltage levels in the telephone plant. These limits are: for continuous AC voltages, 70 volts peak; for continuous DC voltages, 135 volts. Above these voltages, special protection for personnel is being required.

In the TCT System, the normal operating voltages are below these limits. Ringing voltage, which is 40 to 105V RMS 20 Hz superimposed on 48V DC, might appear, at first glance, to exceed the safety thresholds, but ringing is not a continuous voltage. It is interrupted and generally is on for two seconds and then off for four seconds. In addition, ringing supply circuits include sensitive "ring-trip" elements, which sense call answer by detecting the flow of current. These sensing elements (in the supply circuits) are required to function for all ringing operations. They will operate and remove ringing voltage within a small fraction of a second if a personnel contact causes sufficient current to exceed the trip threshold, which is in the range from 10 to 22 ma.

The widespread telecommunication plant is, of course, also exposed to foreign voltages: primarily lightning and high-voltage power distribution plant. Control must be, and is exercised to limit these voltages in the interest of protecting both craftsmen and customers from electric shock. Three techniques are employed to minimize the occurrences of electric shock: (1) the use of protectors and suitable bonding and grounding techniques, (2) the control of insulating properties of station wiring and equipment, and (3) the control of installation practices relating to allowable proximity to sources of foreign voltage.

The protectors that are presently used at central offices and at customer premises are of two types: (1) protectors which are used on all lines with exposure to lightning and power distribution systems, and (2) fuses and other current-interrupting devices which are used on lines exposed to power distribution systems.

The voltage sensitive protectors are generally air-gap breakdown devices utilizing carbon block electrodes. These protectors have a breakdown threshold in the 285 to 540 volt range, are fast acting, and are generally very reliable, provided that proper grounding techniques are used. A comprehensive treatment of bonding and grounding is outside the scope of this paper, but the basic requirement is that all grounds at a given location must be bonded together so that only one ground exists for telephone company equipment, customer equipment, and electric power systems, thereby minimizing voltage differences between separate grounds at the location. All company installers are carefully trained and a considerable amount of effort has been expended over the years in devising installation procedures and equipment to insure consistent, safe, installations.

Protector blocks used in the telephone system can allow up to an 540 volt lightning surge to pass through, but this is not a lethal level because lightning surges are of short duration. Based upon tests on animals, (see Ref 9) the minimum fatal energy for humans is taken to be 50 watt-seconds. An 540 volt lightning surge would need to last of the order of 100 milli-seconds in order to deliver this much energy to a human body, which is more than 100 times the duration of actual surges.

Furthermore, insulation properties of telephone company-provided equipment and wiring furnish protection to levels in excess of the 540 volts that may be passed by the protector blocks. This protection is achieved through appropriate design and manufacture, and most importantly through careful installation and maintenance practices.

The second type of protectors, current-interrupting, or fuse-type, are designed to protect against catastrophic damage to telephone equipment. When used in the central office, they are called heat coils and operate at a current of about one-third of an ampere.

(b) Extent of Personnel Exposure

As explained, the TCTS provides service to customers by means of physical conductors in the exchange plant. Each time service is installed, removed or repaired, craftsmen make physical contact with wire pairs and terminals at one or more points in the station equipment or at the terminal appearances of the wire pairs on customer premises, in outside manholes or on poles, and in the central office building.

In general, the work operations require a hands-on type contact. The size of the wires, the terminal sizes and spacings, and the dexterity required, generally preclude the use of protective clothing or devices such as rubber gloves. This is not to say that rubber gloves are never worn. They are prescribed for many construction operations, particularly when working on joint-use poles shared with power companies. But they are inappropriate for such tasks as splicing together multiconductor fine-gauge cables.

It is difficult to determine the magnitude of craftsman exposure. In the interest of appreciating more fully the extent of this exposure, a form of mathematical model was constructed which is designed to aid in the evaluation of exposure by generating a rough quantitative estimate.

Some of the physical characteristics of the loop plant were explained briefly in Section 2 of this paper. As described there, the conductors which leave a central office building are carried in densely packed cables, ranging from as few as 6 to as many as 3000 pairs of conductors per cable, and they are spliced together and terminated on closely spaced terminals in cross-connection boxes and in sealed splices along the routes.

One consequence of this compactness is that it is difficult for craftsmen to work on a pair of terminals (or a pair of wires) without contacting adjacent terminals (or wires). Therefore, craftsmen working on a single pair are exposed not only to that one pair at terminal field appearances, but also to additional pairs which are connected to adjacent terminals. The extent of this enhancement of exposure is a function of the actual terminal designs (horizontal and vertical separation of terminals, barrier sizes, etc) and the dexterity of individual craftsmen.

A model of a typical terminal field, which defines the immediate exposure area, is shown on Figure 9. This model is based upon a screw terminal field with typical terminal center-to-center spacings of 3/4 inch. (Newer, so-called quick-connect terminals, have spacings of 1/2 inch and less and the trend toward greater compactness is continuing). Assuming a conservative figure of length of exposure span somewhere between one and two inches, the model (Figure 9) arrives at an exposure enhancement ratio, which is the ratio of the number of terminals to which the man is exposed to the terminals actually worked upon, of 15 to 1.

An extension of the model is necessary to account for the overall exposure in performing a work function (e.g., installation of service) because of the multiple appearances of the wire pairs in several terminal fields along the route. Figure 10 derives an overall exposure enhancement ratio, and utilizing a numerical example based upon an assumption of work in four terminal fields per job (e.g., central office main frame, central office equipment frame, outside plant manhole terminals etc) suggests an overall exposure enhancement ratio between 30 and 60 to 1. In other words, the number of pairs of conductors (perhaps including a pair carrying a foreign hazardous voltage) that may be contacted by telephone company personnel is 30 to 60 times greater than the number of pairs of conductors that actually are required to be worked upon.

The next step in deriving an overall craftsman exposure scale factor is to determine the volume of work performed in the exchange plant. While this is a difficult figure to define precisely, a lower boundary can be found from work order and repair activity. For Bell Canada, there are over 0.3 million work functions per month involving contact with wire exchange plant, which is a rate of almost 10 contacts per 100 lines per month.

A reasonable estimate of overall exposure may thus be obtained by multiplying this figure of 10 contacts per 100 lines per month by the exposure enhancement ratio previously derived. Results of such a computation yield an exposure rate of about 300 to 600 exposures per 100 lines per month or 3 to 6 exposures per line per month. In other words, a craftsman contact occurs with each loop on the average of about once a week.

This estimate has been based solely upon work order data. In addition, there is the further exposure incurred during plant rearrangements which, as discussed in Section 2 B), are necessary for efficient utilization of the cable facilities. Consider, for example, a craftsman in the process of splicing together two large feeder cables. He may be sitting in a damp manhole with literally hundreds of wire pairs in his lap. In this situation he has no indication that any of the wires carries a dangerous voltage.

B) Signal Levels

In the trans-Canada system signal levels have been selected to obtain the optimum balance between signal-to-noise ratio and system overload. (Figures 3 and 4 outline these relationships.) If cable is properly maintained the effect of high level signals will occur first, not as cross talk in local cables, but as overload of carrier systems and, as indicated in Figure 4, a marked increase in the probability of intelligible cross talk appearing in these carrier systems. Crosstalk in local cables will increase at the same rate as the interfering signal is increased i.e. if e_B of Figure 8 is doubled in value (increased 6 dB) the signal measured on Pair A will also double. In the carrier system represented by Figure 4, if the signal level exceeds the design level the probability of cross talk increases at a faster than linear rate. For example if a signal level is doubled (above the designed limit) the probability of cross talk increases not by a factor of 2 but rather of a factor of 4 to 8 depending on the design of the particular system.

There is another difference between cross talk in cables and cross talk caused on carrier systems. The signal received in the cable as cross talk will be the high level interfering signal. The signal received as cross talk in the situation represented by figure 4 will usually not be the high level signal but will be one of the other signals being carried on the carrier system at the same time. In the latter instance, since the cross talk heard by a listener is not the signal causing the cross talk to occur, the problem of tracing the trouble becomes extremely difficult, especially so since the problem may be detected as a problem thousands of miles from its source (this can come about since the carrier system is only one entity of the over all system described in figure 2).

For these reasons the level of energy on voice frequency circuits in the range from 300 to 3000 Hz has been set at the average level of -12 dBm0 at the local central office as indicated in Section 2 A).

The presently used ringing signal of 20 Hz at 40 to 105 volts would appear at first glance to violate the requirements of signal level. However, this signal is sent only from the local central office to the terminal at the subscribers premises and is never sent in the opposite direction towards the toll centre and the carrier system. On local loop plant the level of 100 volts represents +40 dBm. As mentioned in the preceding section on Cable Balance, cross talk coupling is normally of the order of -100 dB. The crosstalk level can be calculated as follows:

Ringing Signal	+40 dBm (max)
Cross talk coupling	-<u>100</u> dB
Cross talk level	-60 dBm

(The signal the calling party hears as "ringing" is not 20 Hz energy but a lower level, higher frequency signal to indicate the application of 20 Hz to the called terminal).

From the point of view of listeners the telephone instrument greatly attenuates energy coupled to the ear at these very low frequencies (see reference 6) and in addition the human ear is also much less sensitive (see pages 398 to 401 of reference 10). Data transmission is also insensitive to energy at these low frequencies.

Noise

As with most parameters the noise level objectives are based on economics where the risk of customer dissatisfaction must be weighed against the cost of control. Surveys represented by information such as figure 5 are used to define measurable values of noise against which existing plant can be evaluated and maintained and new plant can be designed. The overall objective of message circuit noise is to have the quality of service in the range of good or better on 99% of all short connections and on 90% of the longest connections (see reference 11).

It must be mentioned here that even slight longitudinal unbalance of the terminal, as discussed in the section on cable balance, can produce noise levels greatly in excess of this objective to the detriment of users on both ends of the circuit.

The noise so far discussed has been message circuit or continuous noise (hiss). Impulse noise also occurs, which, as the name implies, is caused by a sudden change in potential. Impulse noise is characterized by "Pops" in the telephone receiver and is typically generated by the opening or closing of a switch contact in an inductive or capacitive circuit, for example, interrupting the current in a relay winding. High levels of impulsive noise cause high error rates to appear on data circuits.

Impulse noise can be held to low levels by proper system design and maintenance. The generation of noise can be controlled at the source by maintenance of switch contacts and by adding suppression devices. Interference with other circuits can be reduced by providing good longitudinal balance, space separation and shielding. Even relatively simple electromechanical devices such as teleprinters pulsing on DC loops can cause impulsive interference to the circuits if not suitably designed and filtered. If these devices are operated unbalanced with one side of the loop grounded the level of impulse noise on adjacent circuits can be intolerably high.

C) Supervision and Signalling

Signalling and Supervision is the process by which the terminal and the central office indicate to one another what service is desired by a customer and how to provide that service. It is the means by which the terminal is informed that an incoming call is present, the means by which the local central office is informed that service is desired, what connections should be made through the network, and when the call is ended. Any errors or vagueness (marginal conditions) in the signals interchanged can and will result in failure to perform the desired functions. There are three entities in this chain of command, viz, the terminal, the subscriber's loop, and the local central office, and the characteristics of each of the other two must be considered in a discussion or design of the parameters of any one.

Supervision

Supervision is the process by which the local central office can detect if the terminal is calling for service, or has completed a call. It is the proper functioning of supervision which enables a customer to indicate his desire to place a call and enables the communicating system to automatically record and time that call when required for charging. When the terminal is on hook (i.e. idle) the loop should appear as an open circuit to the central office. When the terminal is off hook (i.e. in use) the central office should see a loop whose far end is shunted by a resistance of about 200 ohms. If the current flowing in the loop exceeds a certain minimum (which is a function of the particular kind of central office in use) the office will reliably detect this and provide dial tone or whatever else it is supposed to do at that particular point in time. If an improper condition exists such as too great resistance in the terminal at the end of a limiting loop, the office may or may not detect the condition and the risk of unreliable service greatly increases.

At the end of use the terminal must again open the circuit at the end of the loop which will cause the current in the loop to drop below about 1 ma and the central office will detect this as an on hook signal. Although the loop conductors in the cables are insulated from one another and from ground, no insulation is perfect, and therefore some leakage will occur. Since it is a costly process to repair cables every time slight leakage can be detected the central office equipment is designed to accommodate a certain amount of leakage based on the premise that the leakage at the terminal will be nil. Here again the degree of risk and the amount of control required has been balanced to provide the best economical system.

It is interesting to note at this point that newer designs of central office permit supervision over longer loops. For example, step by step offices only permit loops of resistance up to 1300 ohms, #5 crossbar central offices limit the loop resistance to 1500 ohms and electronic switching offices permit a loop resistance to 1700 ohms. Today in Bell Canada there are about 630 entities of step-by-step serving 2.5 million lines, 360 entities of #5 crossbar with almost 1.1 million lines and 6 new electronic switching offices serving about 70,000. Future plans call for gradual replacement of step-by-step by electronic switching offices. Subsequently digital switching will be introduced to complement digital carrier systems.

Signalling

Signalling is the process of indicating to the central office what is required, as by dialing, or of the central office indicating to the terminal what is desired, as by ringing. Although signalling and supervision are similar in some ways they differ in that supervision tells the central office when the system is required and when it is no longer required while signalling indicates to the central office or the terminal what is required. Signalling involves function per unit time whereas supervision does not.

The ringing signal has been discussed previously. It is commonly a 20 Hz alternating current signal used to inform the terminal of an incoming call and, in some services, to cause the terminal to automatically answer that call and go off hook. Other forms of signalling can be used for this purpose, such as specific frequency tone signals at much lower levels, and are expected to be used in the future, (probably beginning within the next 10 years) increasing as economics permit. Although it has been shown that the present high voltage ringing signal is not hazardous to the life of the craftsmen, it can be uncomfortable to encounter. Also, it cannot be used for signalling through the network because of its high level and low frequency and is not compatible with solid state switching. For these and other reasons it is considered a candidate for change as soon as economics permit.

The other signalling function is that familiarly known as dialing in which the user indicates to the central office the electronic address of the terminal to which he wishes to be connected. The majority of loops in Canada are arranged for dial pulsing where the address is indicated by a series of pulses of current caused by interrupting the loop current at the terminal. A newer system, known as Touch Tone has been introduced and is being made available to increasingly large numbers of customers. Touch Tone uses combinations of two tones to indicate the numbers of the address.

Dial pulses are most commonly generated by what is known as a rotary dial. This device is designed to open and close a contact in series with the loop at a precisely controlled rate and for a precisely controlled time. Figure 11 indicates the open and closed condition of the dial contacts and shows the idealized current wave form through these contacts. The opened or Break interval is t_o. The closed or Make interval between two open pulses in a pulse train is t_c. $T = t_o + t_c$. The interdigital interval is t_i. The two parameters which must be closely controlled within the dial are the number of pulses per second given by $1/T$ and the percent break by $t_o/T \times 100$.

At the central office the dial pulse receiver must recognize the trains of pulses and act upon them. By counting the number of pulses in a given train it recognizes the digit that was dialed (5 pulses for the digit five for example) and recognizes the end of one digit and the beginning of the next by the interdigital intervals t_i.

All pulse receivers in the step-by-step offices must directly and reliably actuate step-by-step rotary switches. The rate at which these switches operate obviously sets the maximum number of pulses per second for the system. The lowest number of pulses per second is set by the need to differentiate between the length of the Make interval, t_c, and the interdigital interval t_i. There must obviously be some margin beyond each of these limits and there is.

The loop, as we saw in the discussion of cable balance contains an appreciable shunt capacitance per mile. In addition, it often contains series inductance to improve its high frequency response (this is known as loading) and, of course, series resistance. These three parameters combine to add distortion to the clean pulses of figure 11 so that the edges of the pulses become rounded and more difficult to detect reliably.

Based on these considerations rotary dials are designed to the following specifications. New dials must operate between 9.5 and 10.5 PPS and 58 to 64% break. Repaired dials must operate between 9.0 and 10.8 PPS. In-service dials may vary between 8.0 and 11.0 PPS. Excursions of the percent break or the in-service pulse rate beyond these limits will result in dialing errors, wrong numbers and retries to the annoyance of the user, and if wide spread, can result in a markedly greater equipment usage than was predicted by the theories of probability and risk which were based on these limits.

Touch Tone Signalling

The Touch Tone concept, first introduced in 1962, provides a more convenient and considerably faster method of signalling than the older dial pulsing. As shown in figures 12a and b there are two groups of 4 tones each used in this process and each digit must contain 1 and only 1 of the frequencies in Group A and one and only one of the frequencies in Group B. (Although the B frequency of 1633 Hz is not used in the standard dialing unit, it was provided in the Touch Tone planning so that it would be available for future use. It has been used in some special purpose systems.)

It is obvious that a signal produced by the Touch Tone unit has some self checking features. For example if the local central office receives more or less than one frequency from each group the digit is not a legitimate digit. Pushing two buttons at once will fail one of the two required tones and the central office will not act, thereby preventing wrong numbers.

A central office used with Touch Tone must have a Touch Tone receiver. One of the advantages of Touch Tone is that the loop distortion which limits the distance of dial pulsing does not have any great effect on the Touch Tone signals. In fact Touch Tone signals can be transmitted from end to end through the network (end to end signalling) without difficulty. However the Touch Tone unit in the terminal and the Touch Tone receiver in the central office must still be designed to compliment one another, and those characteristics of the loop which do effect Touch Tone signals and Touch Tone dialing must be considered.

Fig 12 shows the variation of power output with frequency which helps to compensate for the greater signal loss at higher frequencies and also shows how the power output varies with loop current, being greater for low currents which are encountered on longer loops with higher loss. These latter considerations minimize the range of signal power which the central office receivers can expect. The frequencies from the Touch Tone unit at the terminal must be kept to a tolerance of plus or minus 1.5% and extraneous signals must be at least 20 decibels below the total signal power. These tolerances apply over a temperature range of -30° C to +55° C and include not only manufacturing variations but also in service limits. Here again is an example of the various entities being designed to complement one another.

In Section 3 B) it was indicated that the average signal power at the central office should not exceed -12 dBm0. From Fig 12B and typical loop and central office losses it can be calculated that the average power from a touch tone unit at the central office will be about -6 dBm0. However, on the average the ratio of the time the tone is on to the time it is off during dialing will be less than 25%, and this means that the average power is therefore less than -12 dBm0.

The arrangement of the keys in Fig 12A was arrived at after many subjective tests were performed with different numerical arrangements. It resembles, but is not identical to, the numerical arrangement of an adding machine. The arrangement adopted was the one which resulted in the fewest wrong numbers being presented to the system by the users. (It is interesting to note that many of the newer calculating machines are now adopting this same arrangement in preference to their earlier one.) The least significant digits are at the top of the dial while the most significant is at the bottom (0 is always used to denote 10).

Attention was also paid to the button design with respect to resistance and distance of travel to minimize errors by requiring a full key depression which assures signals will last for at least 40 ms so that the receiver at the central office will have sufficient time to respond. All of these parameters have been based on the research-development-experience cycle.

It should be noted here that while #5 crossbar and electronic central offices can be readily equipped with Touch Tone receivers, the older step-by-step offices would be very expensive to convert. As these older offices are gradually replaced with newer ones in the normal course of events the replacing ones will be equipped with Touch Tone.

Section 4

Interconnection of System

As we saw from figure 2 and the discussion of Sections 2 and 3 each of the entities in the Canadian Telecommunication System has been designed to complement the others in order to arrive at a grade of service whose parameters of transmission quality (such as noise level, signal-to-noise ratio, bandwidth, etc) and signalling and supervisory sub-systems all fit together to provide the grade of service which many preference tests with groups of people have shown the subscriber really wants. The North American Telephone System (Canada and the United States) is considered to be the best in the world. In the Trans-Canada Telephone System the parameters we have been discussing have been carefully chosen and rigidly adhered to in the design and maintenance of the overall system. Close watch is kept to detect any sign of potential or actual deterioration from these standards in order that remedial steps can be taken before a serious deterioration occurs. To avoid catastrophic problems the switching system has a wide range of alternate routings to chose from, as indicated in Figure 1, long haul microwave systems have standby channels and automatic switching to them in case of failure of a working channel, etc. We have seen how every entity of this system affects all the others.

If, to a system designed to meet certain limits of noise, bandwidth, distortion, and so forth, we attach, in tandem another system designed to meet the same limits, then it is well known to any system designer that the new overall system will fail to meet the limits of the original systems. Simply put, no transmission medium can produce at its output any better signal than that which was presented at the input, and in a real system there is always some deterioration of the presented signal.

If two or more systems are to become sub-systems of a larger system, then, as we have seen, each of the sub-systems must be designed so that the desired overall quality is met, which means the sub-systems must be designed to a higher standard.

The members of TCTS offer to their customers Private Branch Exchange (PBX) service. In order to meet the overall objectives of the Telecommunication System, loops feeding these PBX's from the central office are not permitted to have either as high a resistance or as great a loss as those feeding individual terminals. This assures that the terminals connected to the PBX will be assured of a good grade of service when they connect through the PBX through the larger network. The standards, however, to which the PBX is designed are equally as high as those to which the network is designed. Reliability is high and maintenance must be of a suitable calibre and frequency or the PBX could cause the same troubles of supervision and signalling to and from the central office that were discussed in Section 3.

The design of a communicating system requires a thorough knowledge of the various parts of the system, including the terminal, and the often subtle interactions between these various parts. Because of the changes that are continually being made to the TCT System and because of the inter-action between the various parts of this system it is imperative that the members of the system retain full control over the system. Without this control the member companies would certainly be impeded in making economical technological changes in many instances and could be prevented from doing so in others because customer owned inter-connected systems might not be able to accommodate these changes. Two such changes which are expected to occur within the next 10 years or so have already been mentioned, viz, digital systems and a trend away from 20 Hz ringing. A customer with a connected system, as is human nature, would be very loath to replace portions of his satisfactorily operating system because a member of the TCTS found it economic to change from analogue loop distribution plant to digital or wide band technologies. The same reluctance would occur to the change from 20 Hz ringing. Again, if economics and technology permit, Touch Tone signalling will become very common and the dial pulse systems will disappear - at this point in time new central offices will no longer be designed to accept dial pulse signals and a customer's system, which depends on inputting them would be unworkable.

Certain restricted inter-connection with customer owned systems such as paging systems, could be workable where the communication requirement is of the "in-house" type, and does not involve "anywhere to anywhere" network connection. In this situation, since PBX systems provided by members of the TCTS are designed and maintained to be part of the network system, their parameters are not limiting. Since the customer-owned paging system would not have access to the public address network it would not be in tandem with a limiting system and transmission quality could be maintained. Also the network would not be affected. Where such interconnection is logical and reasonable (considering technical requirements, risks, necessary control) it could be considered subject to suitable agreements concerning parameters, controls, and maintenance.

Section 5

Interconnection of Common Carriers

Common carriers have as a primary technical objective the intent to protect and improve the telecommunication environment for the benefit of all users. Since the carriers sell service, maintenance of service is of paramount importance and the appropriate plant personnel are trained accordingly. Usually the primary systems and important services are maintained on a round-the-clock basis while services of lesser importance are maintained on a daily basis or as required. Interconnection among Common Carriers jointly providing a service, for example members of the TCTS, has been carried on for many years by agreement between the parties and with a minimum of difficulty or disruption. These points of interconnection are carefully specified as to location and characteristics and the parties have both a prime interest and the ability to meet and maintain these agreements. Over the years the Telephone Companies in Canada and in North America have developed technical, administrative and operational standards, procedures and practices which ensure effective interworking of the systems to the advantage of the public community.

Other existing carriers have evolved their own techniques and administrative procedures which are well suited to their particular needs. Where these are significantly different (for good reason) maintenance and system design problems are created when the systems are interconnected.

Limited or special purpose carriers, such as the telecommunications arm of the Hydro companies may have standards and service requirements which are significantly different, either higher or lower than those of Common Carriers, and in this case also significant interconnection problems can be expected.

Section 6

Connection of Terminals

Connection of common carrier facilities and customer owned terminals is an area which to many users appears to offer a lower cost alternative to services offered by the common carriers or offers services not offered by the common carriers. As we have seen in Sections 2 and 3, it also offers the potential for serious harm not only to certain elements of common carrier hardware but also to the use by others of the public address network. Since the common carriers could exert little if any influence on the design, usage, and above all maintenance of customer owned terminals they are very concerned about the consequences of interconnection.

The common carriers are continually applying effort to improve the quality of service (eg. reduce noise and attenuation, increase reliability, reduce costs, etc.) provided to their customers. This is an ongoing activity which must continue if the public is to be well served in an era of rapidly changing technology. When the carrier owns all parts of the system a natural overall information "feedback" path exists which often serves to highlight areas requiring improvement. If ownership is split, as with customer provided equipment, this feedback path is broken and identification of problem areas is made more difficult.

From the point of view of the buyer the requirement is to obtain the desired function for a minimum cost, and his shopping is usually based on the comparison of first cost or purchase cost of the hardware available from different manufacturers, since he is often in no position to compare maintenance and operating expense. In this competitive market the manufacturer must attempt to build hardware at minimum cost and this may reduce incentive on his part to put major emphasis on the characteristics of stability, reliability, maintainability, compatibility with requirements of the network, which are of paramount importance to the common carrier.

As Sections 2 and 3 have shown, the public address network and private line facilities are built up of the same entities as shown in Figure 2, the only difference being the absence of switching and the individual design in the private line case. In both situations, since the individual entities have a probabilistic nature, the overall facility will also have a probabilistic nature (i.e. any given parameter can be expected to vary by some amount from its mean value for all such circuits taken together). The unsophisticated buyer of terminal hardware, unfamiliar with, or even unaware of the existance of, these variations (and not interested in them since communications is only incidental to his business and not his prime purpose) can well be misled by manufacturers.

The statement "hardware designers are typically ingenious - system designers must take a long view" applies very well here. The system designer must consider each aspect of his work in terms of its overall effect on the system, the service to be provided and the economic and technical trade-off over the long term. This statement summarizes the fundamental difference of purpose between the terminal equipment supplier and user on the one hand and the communication supplier on the other - the first is interested in providing a specific function for himself, while the latter is interested in providing and maintaining a specified grade of service to all users.

If customer owned and maintained terminals were to be connected directly to the facilities of the Telecommunications systems there is one major parameter that a customer might be strongly tempted to violate. This violation would be of the level of signal power applied to the system because a lower error rate in voice or data services can almost always be achieved by obtaining a greater signal-to noise ratio and a greater signal-to noise ratio, for a given level of noise, can be achieved by raising the sending level. In addition he may inadvertently, because of lack of knowledge, lack of interest, or lack of maintenance, violate others to the detriment of the overall Telecommunications system.

Sections 2 and 3 describe the local cable crosstalk, and the more serious and insidious intermodulation crosstalk due to carrier overload. Since the customer's prime interest is his own communication, and since his operations are not affected by so doing, the temptation to raise his sending levels is not balanced by any adverse effects that he can detect. As indicated in Fig 4 and discussed in Section 3, very little increase above the -12dBm0 average level can rapidly increase the probability of intelligible crosstalk in the carrier system. This sort of interference or overload can be tracked down, with considerable difficulty, on dedicated private line facilities, but because of the probabilistic nature of the switching function of the network, as intimated in Figure 1 and discussed in Sections 1 and 2, this type of overload is almost impossible to find on the public address network.

With respect to the signalling and control functions described in Section 3 similar problems arise. Failure of a signal mechanism such as a dial to consistently adhere to the requirements of Section 3 will result in mis-dials and wrong numbers. The consequent annoyance to the wrongly called parties, the requirement on the part of the Telecommunications system to manually rebate the accounting for mis-dialled long distance calls, and the increased use of the central office as the user tries again all represent undesired situations to the detriment and expense of other users of the network.

Failure or marginal operation of supervisory signals can result in such things as the office failing to go on-hook at the end of the call or a complaint from the user that the office fails to go off-hook and provide dial tone at the beginning of a call, both of which involve plant effort and expense to find the cause of the trouble.

The intent of the preceding discussion has been to indicate the potential problems inherent in terminal equipment from the point of view of adverse effects on the total Telecommunications system and its other users. Defects and troubles in customer provided terminal equipment which would affect only the customer himself, i.e. failure of a data set to transmit data, will not be discussed. An example of the magnitude of the problem is indicated by the fact that Bell Canada, which operates a total of 5.5 million telephones adjusts or replaces about 0.3 million rotary dials annually because of failure to meet the requirements specified in Section 3. These dials are designed and built to rigid standards, and still require regular maintenance.

Type Approval

From time to time the proposal has been heard that customer owned hardware should be permitted to interconnect with the facilities of the Telecommunications Companies provided it meets some sort of type approval which would assure compliance with the requirements of, and compatibility with the facilities of the communications suppliers. After all, electrical apparatus must meet the tests of the Canadian Standards Association Laboratories and be stamped with their type approval numbers before it can be placed into service or even be offered for sale! Type approval for use of equipment on the public address network or private line service and type approval for use on electrical power circuits appears, at first glance, to be essentially the same sort of problem.

In reality the problems are quite different. The purpose of CSA approval is to assure that, when offered for sale, a given device presents a minimum electrical hazard to the user. It does not assure that the hardware inspected will perform the function the purchaser desires. The approval is based on tests made at a given point in time on typical production units provided by the manufacturer to the testing laboratory. It does not guarantee that the hardware will not be modified or changed by the user of the hardware. Changes or modifications by the user can unknowingly invalidate the CSA approval and can result in (a) failure of the apparatus to perform the task for which it was designed, (b) fire on the premises of the user, (c) operation of a protective device to disconnect electrical service to the user, (d) hazard to the person of the user, or some combination of these. None of these four conditions is likely to affect any one but the user himself within his own premises.

Type approval of terminal devices for communications purposes indeed has some similarities to the CSA situation, viz a testing authority, parameters which must be tested for, a procedure to be followed by a manufacturer in order to obtain approval, and a procedure for indicating and listing those items which have obtained approval. However, since faults can occur after approval due to normal use which can adversely affect the communications network and other customers' usage, an initial approval of hardware at a given point in time is obviously not sufficient. In addition, consideration has to be given to maintenance and how to assure that it will be carried out and also a means to detect when the device is faulty for as we have seen terminal hardware may still perform quite adequately a function that the user desires while at the same time adversely affecting the network and the service of other customers.

A question that must be asked of any proposal for type approval is "how does one accommodate technological advances in the common carriers' communication system". It has been pointed out for example that the common carrier's expect a trend away from the 20 Hz rigning signal within the next 10 years and also a much greater usage of digital plant. Type approval parameters based on today's plant requirements would obviously inhibit these changes just as type approval instituted, say, 20 years ago, would have tended to inhibit the quality and variety of services available to the users today.

In the power distribution system purposeful or accidental faults or deficiencies usually affect only the user or at most have a local perturbing effect. This comes about because the user only receives energy from the network. In the telecommunication system, however, not only does the user receive energy from the system, he inputs to it and interchanges control signals with it. It is this fundamental difference between the power and telecommunication systems which makes type approval useful for the one and very risky for the other unless and until effective control of the end-to-end system design and maintenance can be assured at no cost to other users.

Used Equipment

Up to this point, the discussion has been concerned with new customer provided equipment and its potential problems. There are advertisements in the popular press offering used telephone equipment for sale. In the business machine field, there are a number of purveyors of used equipment. Since these equipments have been removed from service for some reason, their present condition and their ability to meet the original design requirements are both open to questions. There is no present practicable means to interconnect with used equipment at low risk except via protective connecting devices.

Connecting Devices

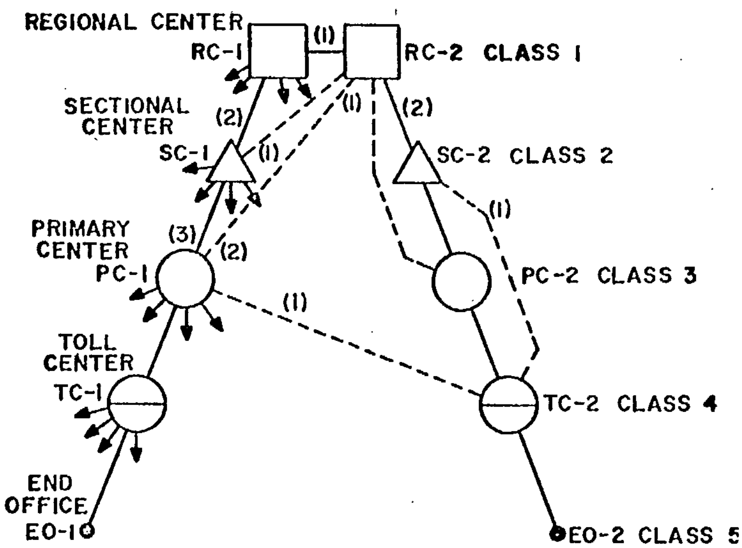
Where a useful purpose can be served to do so, devices can be designed and built by the telecommunications suppliers which will terminate their facilities on the user's premises, permit his hardware to interface via these devices with the network, and at the same time greatly reduce the risk of operational and economic damage to other users of the system. These devices would be designed to be fully compatible with the signalling and supervisory systems currently in use, would present to the user a common and consistent interface, would prevent either by malfunction or intent on the part of the user and his equipment any overload to the network to the detriment of others, and would be part of the economic consideration of the TCTS in planning technological change to the advantage of the network. These devices would be owned by the common carrier and would provide the necessary technological control it requires to continue to operate and administer the present and future networks to the advantage of all users. It must be emphasized here that such devices would not guarantee the successful operation of customer owned apparatus connected to them but would only assure that no disruption of the public address network or private line services occured.

Previous submissions under study 8 b 111 include details of the connecting devices and applicable rates as provided by the TCTS companies.

Table 1

Probability that N or more links will be required to complete a toll call.

No. of Intermediate Links, N	Probability	
	Fig. 1	Bell System Data
Exactly 1	0	0.8
2 or more	1.0	0.2
Exactly 2	0.9	-
3 or more	0.1	0.03
4 or more	0.1	0.003
5 or more	0.010, 9	-
6 or more	0.001, 09	-
Exactly 7	0.000, 01	0.000, 03

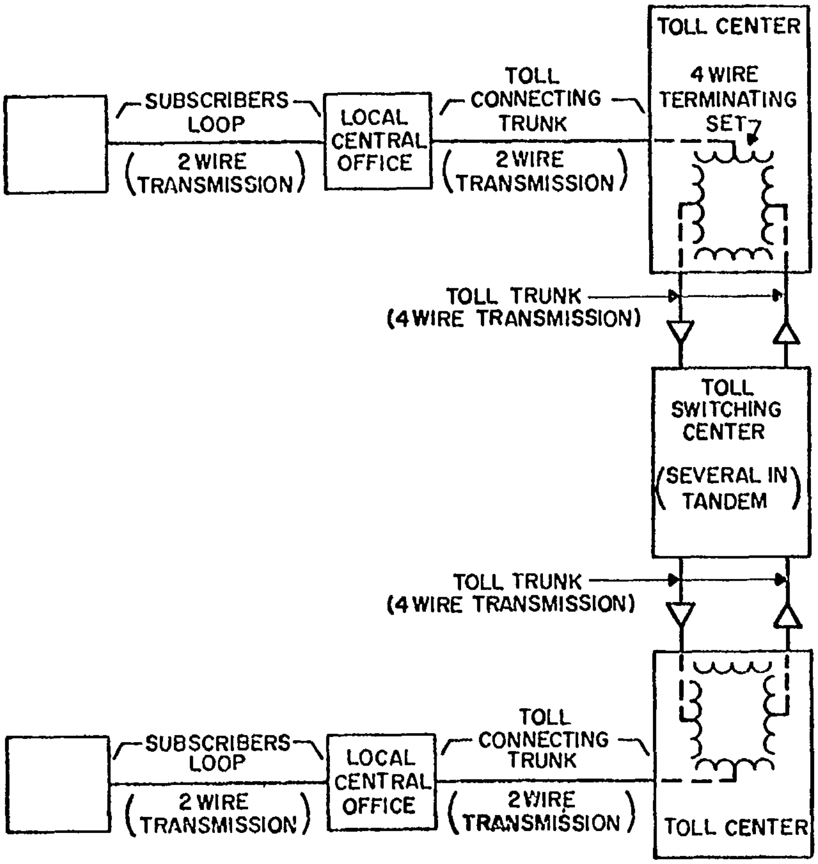


NOTES:

1. NUMBERS IN ( ) INDICATE ORDER OF CHOICE OF ROUTE AT EACH CENTER.
2. ARROWS FROM A CENTER INDICATE TRUNK GROUPS TO OTHER LOWER RANK CENTERS THAT HOME ON IT. (OMITTED IN RIGHT-HAND CHAIN)

Illustration Of Choice Of Routes On Assumed Call

Figure 1



Inter-City Subscriber To Subscriber Connection

Figure 2

95576-14

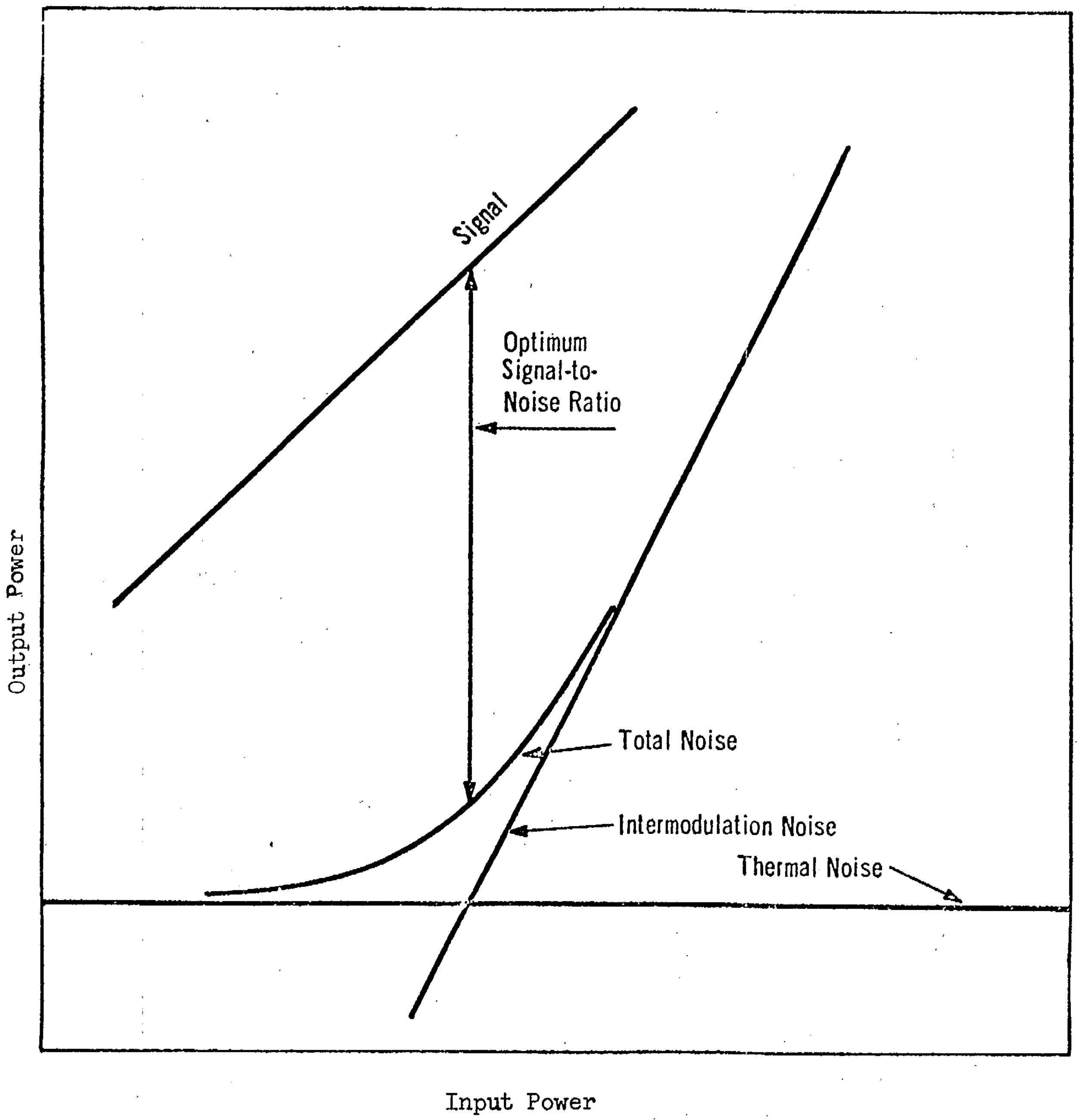


Figure 3 - Relationship Between Signal and Noise Power For Second Order Distortion Limited System.

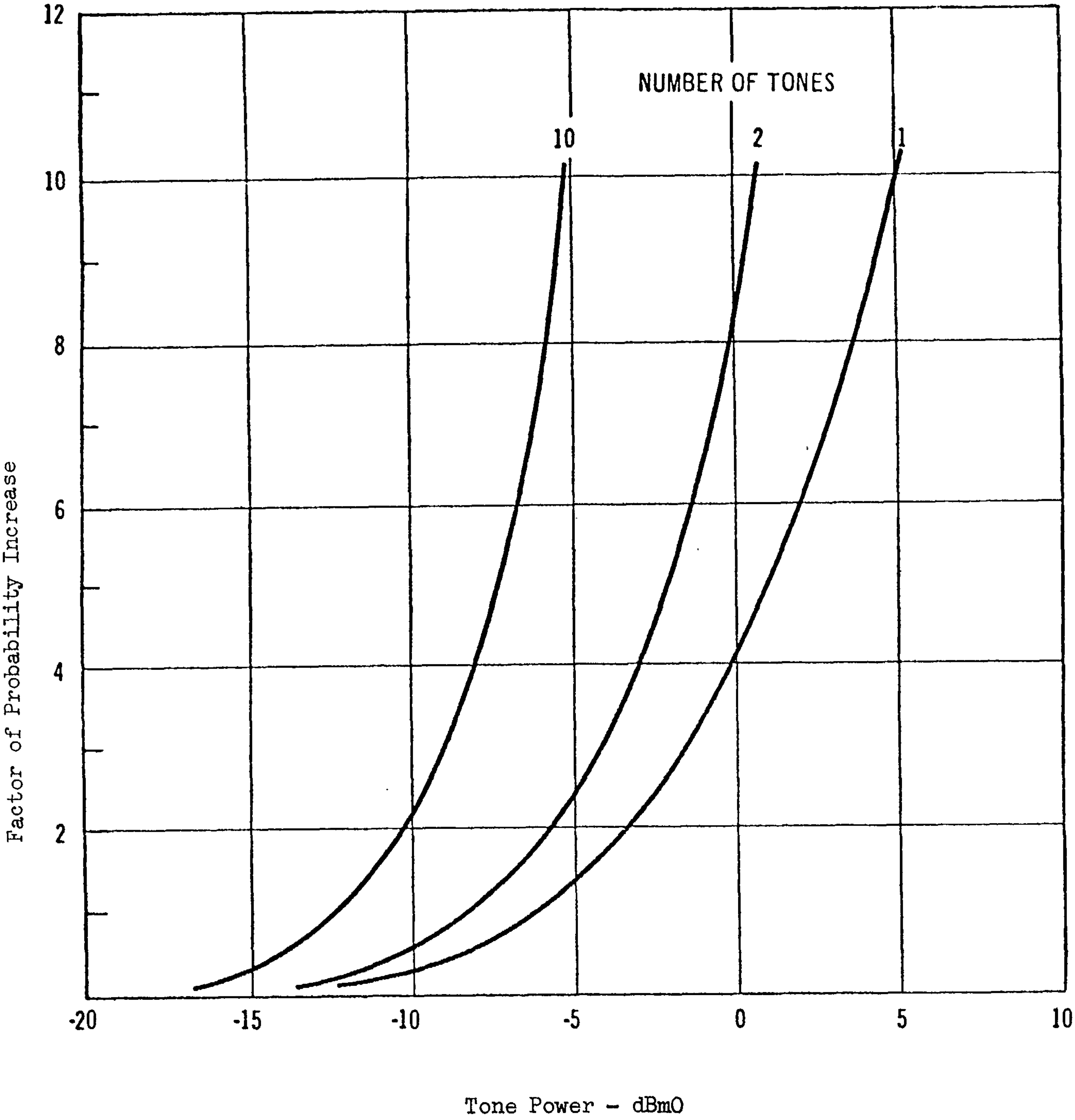
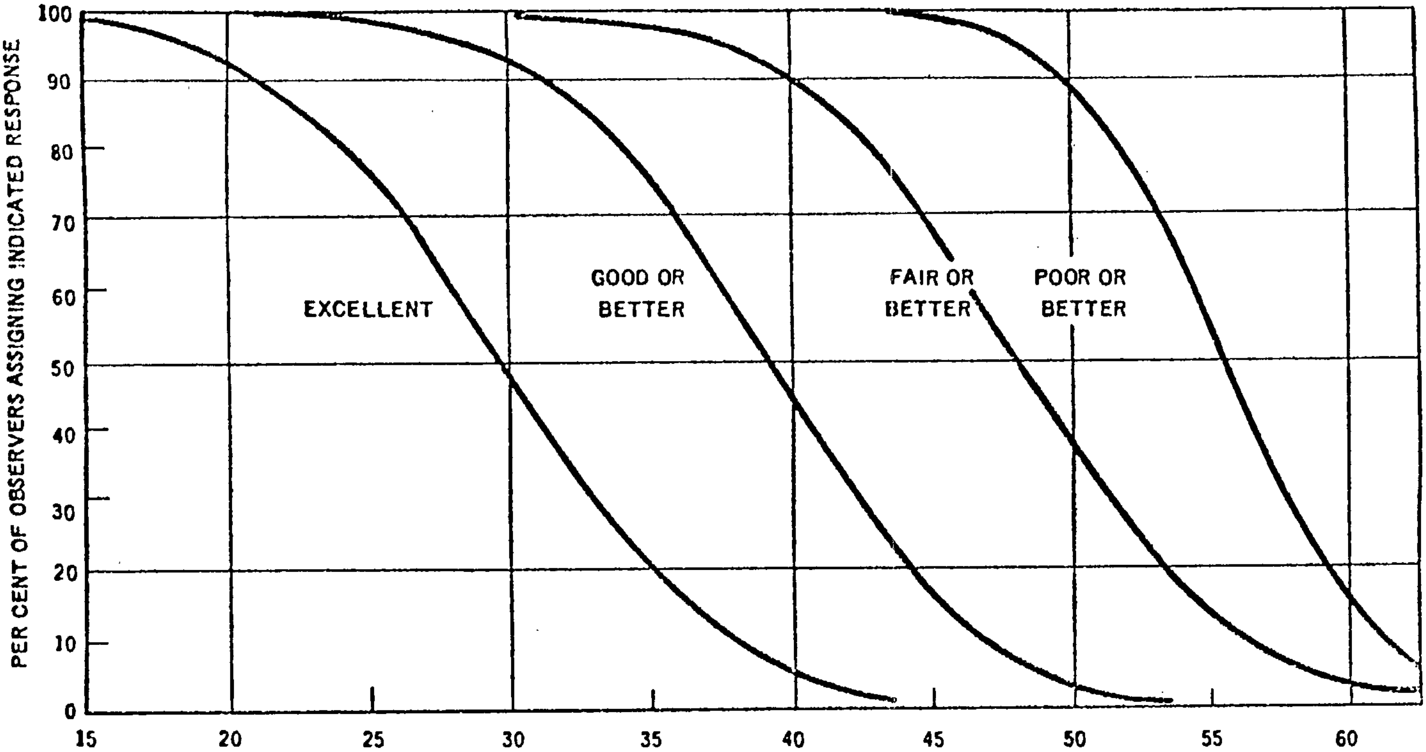


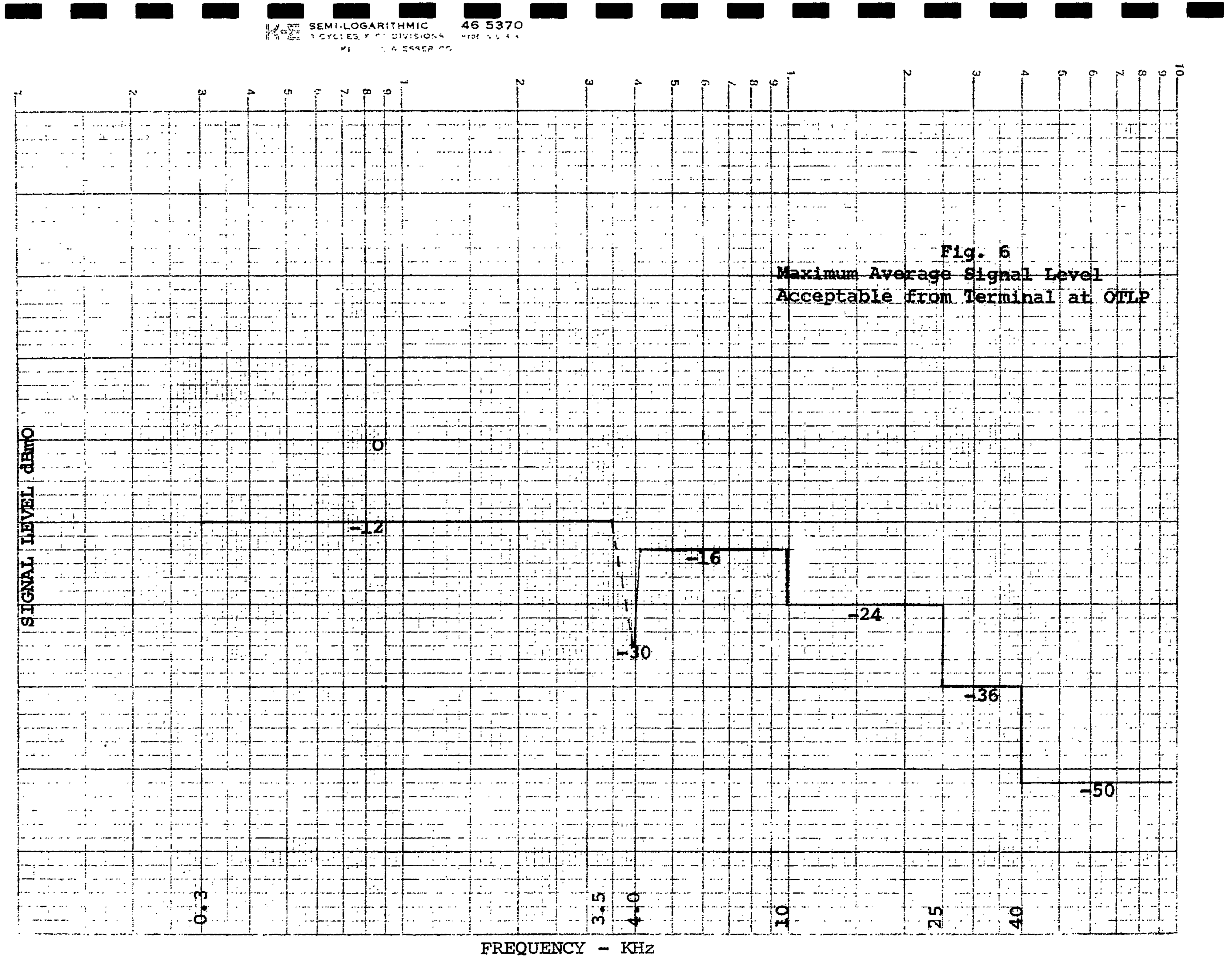
Figure 4 - Probability of Intelligible Crosstalk As a Function of Single Frequency Tone Power.



Noise Level at Line Connections of Station Terminal in dBrnC

* For an explanation of dBrnC, see Reference 1, page 21.

Figure 5 - Subjective Appraisal of Noise Measured At the Station Set.


SEMI-LOGARITHMIC
46 5370
Fig. 6
Maximum Average Signal Level
Acceptable from Terminal at OTLP
SIGNAL LEVEL dBmO
0
-12
-16
-24
-30
-36
-50
0.3
3.5
4.0
10
25
40
FREQUENCY - KHz

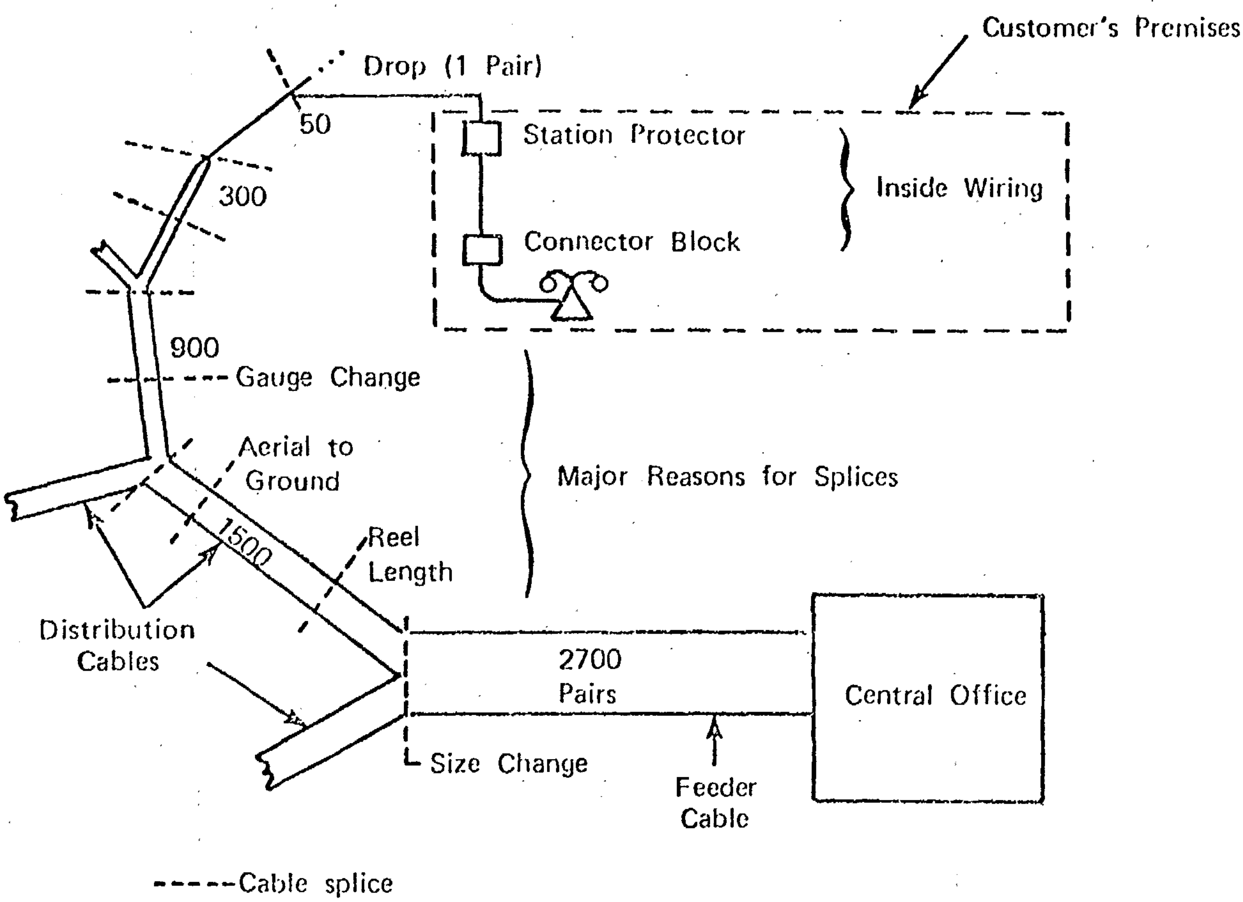


Figure 7 - Typical Loop Plant Layout

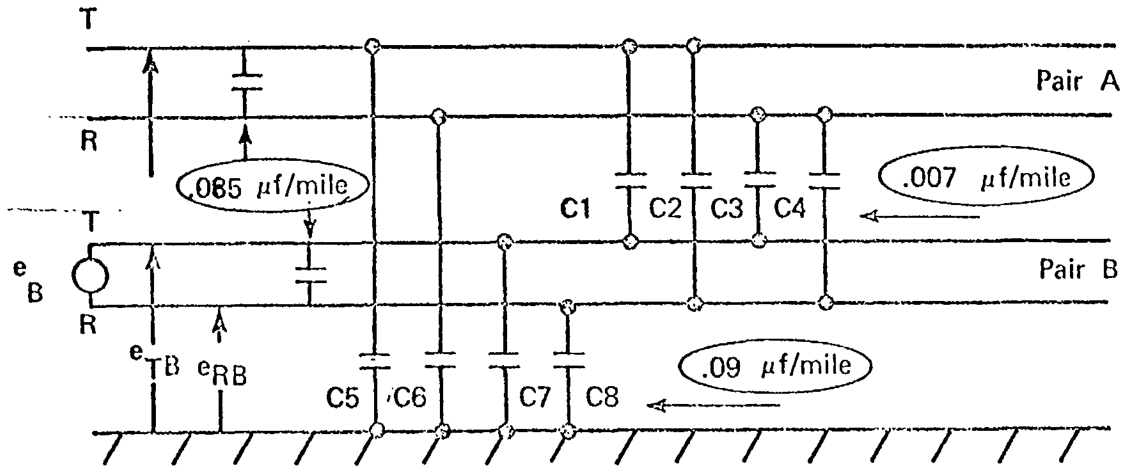
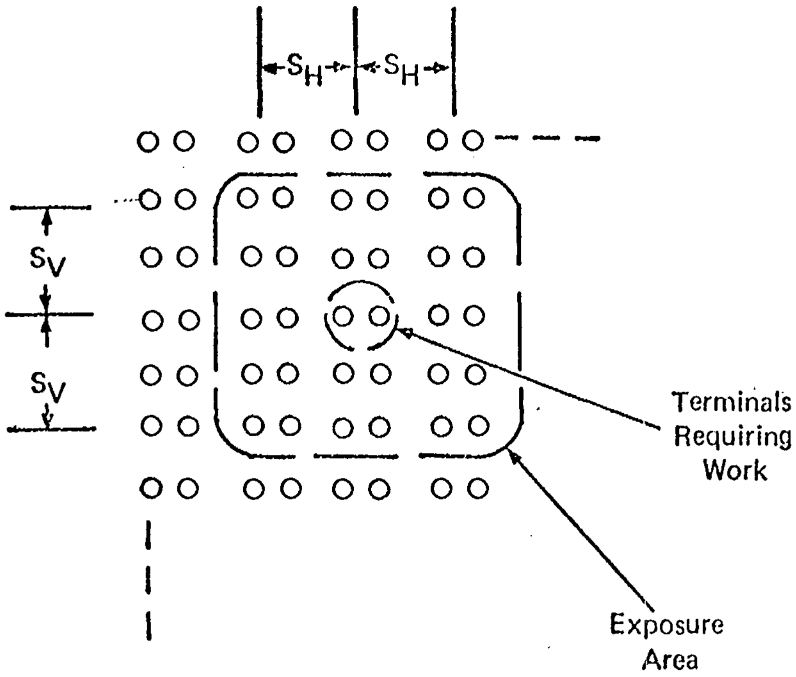


Figure 8 - Simplified Diagram Showing Interaction Paths between Two Pairs in a Cable.



S_H = Horizontal Exposure Span

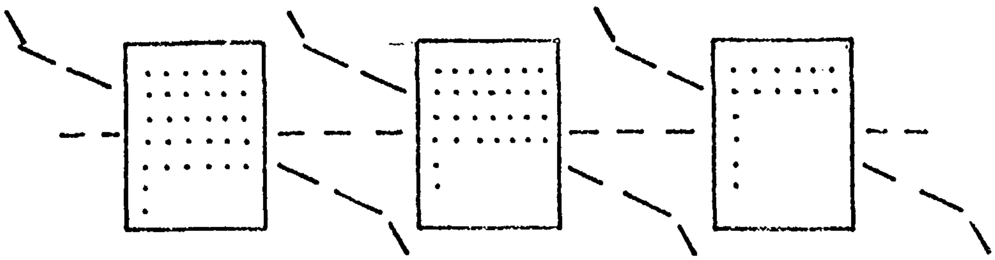
S_V = Vertical Exposure Span

E_E = Exposure Enhancement Ratio

$E_E = (2\ S_H + 1)\ (2\ S_V + 1)$

(Numerical Example) –
Assume (Per Sketch): $S_H = 1$; $S_V = 2$
Then: $\underline{E_E = 15}$

Figure 9 - Terminal Configuration.



$E_{E_1}, E_{E_2} \ldots E_{E_N}$ Are Exposure Enhancement Ratios for Terminals, 1, 2, . . . N, Respectively

(ΣE_E) = Overall Exposure Enhancement Ratio

Upper Bound on (ΣE_E) with no correlation of Wires in Terminals

$$(\Sigma E_E) \leqslant E_{E_1} + E_{E_2} + \ldots E_{E_N}$$

Reasonable Lower Bound on (ΣE_E) with Correlation

$$(\Sigma E_E) \geqslant \sqrt{E_{E_1}^{\ 2} + E_{E_2}^{\ 2} + \ldots E_{E_N}^{\ 2}}$$

(Numerical Example) –

Assume: Work on 4 Terminal fields per job.

$$E_{E_1} = E_{E_2} = E_{E_3} = E_{E_4} = 15 \quad \text{(Per Fig. 1)}$$

Then: $\underline{30 < (\Sigma E_E) < 60}$

Figure 10 – Overall Exposure Enhancement.

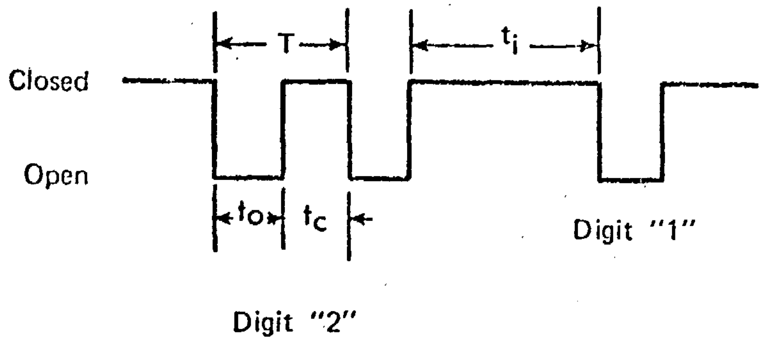


FIGURE PARAMETERS OF DIAL PULSE SIGNALING

Figure 11 - Parameters of Dial Pulse Signaling.

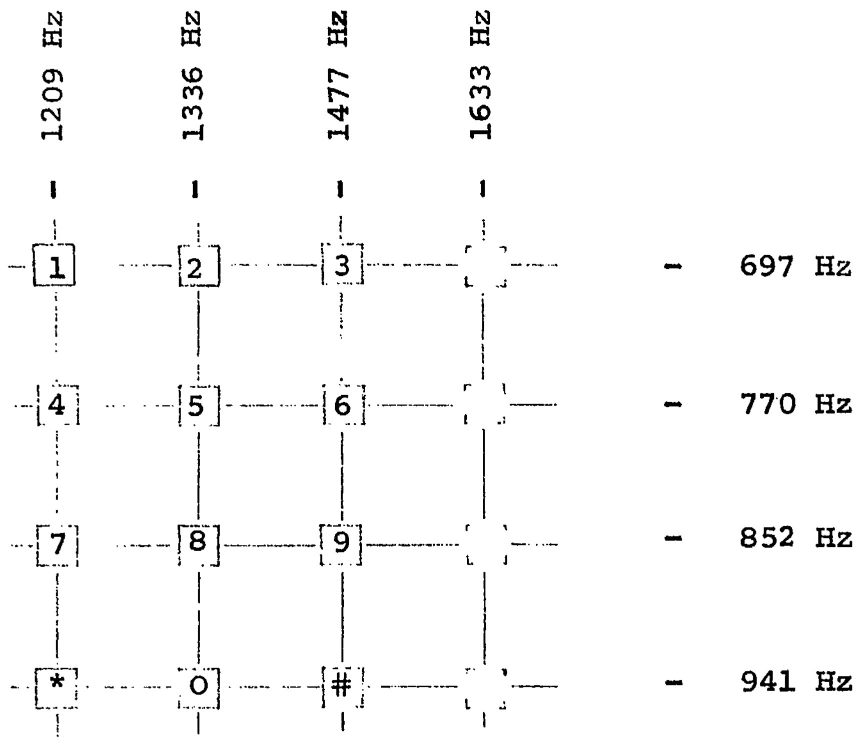


Fig. 12a Touch Tone Dial Unit

Tone Group	Touch-Tone Frequency (Hz)	Line Current 20 ma	75 ma	150 ma
A	697	-3.5 dBm	-7.8 dBm	-10.5 dBm
	770	-3.0	-7.3	-10.0
	852	-2.8	-7.1	- 9.8
	941	-2.5	-6.8	- 9.5
B	1209	-0.7	-5.0	- 7.7
	1336	-0.6	-4.9	- 7.6
	1477	-0.5	-4.8	- 7.5
	1633	-0.4	-4.7	- 7.4

Fig. 12b Typical Output Power of Touch-Tone Unit in dBm into 900 ohm Load.

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