GTE LENKURT

DEMODULATOR

AUGUST 1973

CONCENTRATORS & MULTIPLEXERS

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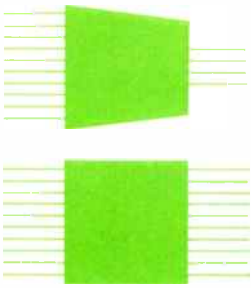

The wires or lines that connect subscribers to the central office are the most inefficiently utilized portions of the telephone system. Concentrators and multiplexers are used to increase line efficiency.

Among the original patents on line concentrators, the following definition was given: "A line concentrator is essentially a switching device which provides for connections between a large plurality of subscriber lines and a small plurality of talking trunks." These subscriber lines can be either physical lines or carrier or multiplex channels. Similarly, a multiplexer is a device for combining a number of individual message circuits for transmission over a common transmission path. When used outside the central office (C.O.), both concentrators and multiplexers require fewer physical circuits to the central office than there are subscribers in the field.

For subscribers located at a considerable distance from the central office, the cost of physical circuits for each subscriber, and the time needed to install them, becomes quite substantial. This is especially true when dealing with a rapid influx of new subscribers. Both concentrators and multiplexers can provide this needed new service quickly and economically. But, they each provide this service in a different way and the grade of service is affected by different factors.

Multiplexers provide a trunk to the C.O. for each incoming voice or data channel by sharing frequency bands (FDM) or time slots (TDM) on a predetermined basis. Thus a multiplexer has the same instantaneous total input and output rate capacity. Concentrators, on the other hand, use a sharing or switching scheme in which some number of input channels share a smaller number of output channels on a demand basis. Consequently, it is not possible to have all concentrator subscribers using their phones simultaneously. For this reason, statistics and queuing play an important role in the planning and use of concentrators in an attempt to insure that trunks are available when needed.

Traffic Loading

Traffic loading has to be considered when planning to use a concentrator for service to remote locations. Telephone service is discussed in terms such as CCS, or erlang, for measuring traffic, and often refers to a grade of service as P(.01). The CCS stands for one hundred call-seconds, or the use of one telephone line for 100 seconds. Since there are 3,600 seconds in an hour, the maximum possible traffic rate on an individual line is 3,600 call-seconds per hour or 36 CCS (or 1 erlang) per hour — this would be continuous usage of the line. The term "P(.01) grade of service" refers to the probability that one call out of one hundred may be blocked due to lack of a free trunk. Similarly, a P(.02) would mean there is a probability of two calls out of one hundred being blocked; P(.03) of three; etc. Good

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central office practices call for a P(.01) grade of service during the busy hour of the average day.

With a multiplexer, the grade of service of the C.O. is not affected and is only a function of the traffic loading. While with a concentrator, the grade of service is a function of the C.O. traffic loading *and* the traffic loading at the remote concentrator.

If a P(.01) grade of service is to be maintained, the number of subscribers that can be accommodated on a single concentrator system is limited, and is dependent upon the amount of telephone traffic that each subscriber generates. The actual traffic will vary from day to day and hour to hour, but there is an average that can be statistically determined. Service will only be degraded to more than one call in one hundred being blocked during the worst peaks of traffic, such as holidays and local emergencies when the calling rate exceeds this statistical average.

The number of subscribers that can be served by a concentrator is also dependent upon the type of service offered. For example, a concentrator system with a P(.01) grade of service designed to serve 96 single-party subscribers, under certain traffic conditions may only accommodate 72 two-party lines or 48 four-party lines. Combinations of single-, two-, and four-party lines can be served by the same concentrator, but the total number of lines offered decreases, for example, to 36 single-party lines, 24 two-party lines, and 24 four-party lines. Figure 1 shows the chart used to determine the number of subscribers in this specific example.

To minimize the number of cable pairs between a remote location and the central office, it is possible for a concentrator system to include a multiplexing technique — transmitting more than one signal on the same transmission channel. For example, a concentrator system that requires 24 cable pairs can serve the same number of customers with only 4 cable pairs if the concentrator is used in conjunction with a subscriber carrier system, such as the GTE Lenkurt 82A. Another concentrator arrangement uses a single (two pair) PCM (pulse code modulation) repeatered line. Figure 2 shows these concentrator arrangements.

A multiplex system such as the GTE Lenkurt 910A uses a PCM line to serve 24 customers over two cable pairs, or 48 customers over four cable pairs, and provides each of these customers with total access to the central office at all times. Each of these 24 single-party lines can be used for two- or four-party service, making it possible to increase the number of subscribers to 96 per two cable pair. Figure 3 shows the line arrangement using a multiplexer.

If the area served by a remote concentrator or multiplex system grows to the point where it is economical to put in a central office, an existing PCM multiplex system can be used to provide the trunks between central offices. The concentrator equipment may have to be removed and additional multiplex equipment put in for inter-office trunk requirements, if there are not enough cable pairs available.

Simultaneous Requests

Simultaneous originating and terminating requests made on a concentrator must be queued (lined up) and served preferentially. The concentrator may be simultaneously summoned by more than one line at the remote terminal requesting connection to the central office network. It is also possible for two or more callers to initiate termination requests that reach the

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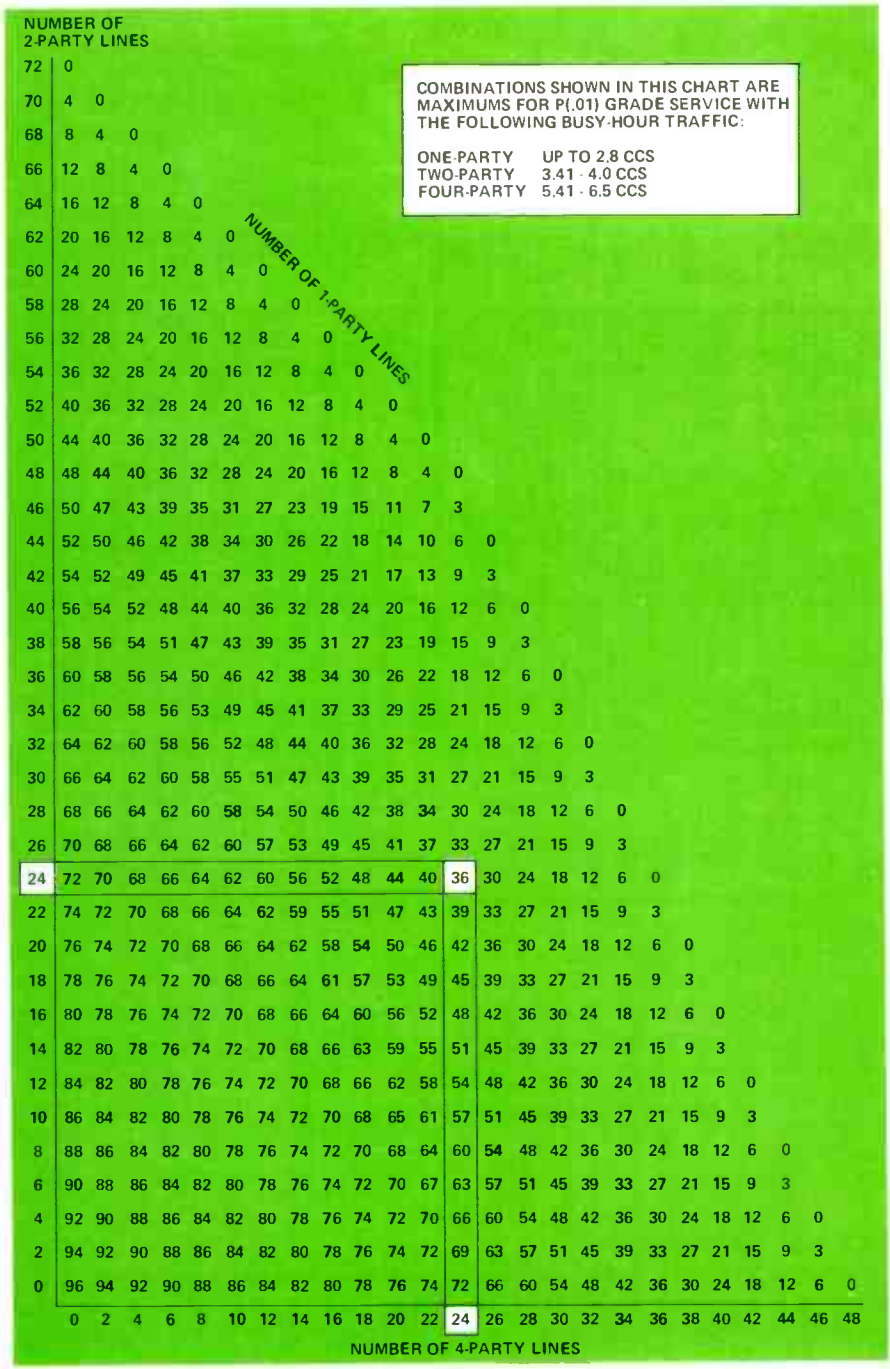

2-party lines \ 4-party lines	0	2	4	6	8	10	12	14	16	18	20	22	24	26	28	30	32	34	36	38	40	42	44	46	48
72	0																								
70	4	0																							
68	8	4	0																						
66	12	8	4	0																					
64	16	12	8	4	0																				
62	20	16	12	8	4	0																			
60	24	20	16	12	8	4	0																		
58	28	24	20	16	12	8	4	0																	
56	32	28	24	20	16	12	8	4	0																
54	36	32	28	24	20	16	12	8	4	0															
52	40	36	32	28	24	20	16	12	8	4	0														
50	44	40	36	32	28	24	20	16	12	8	4	0													
48	48	44	40	36	32	28	24	20	16	12	8	4	0												
46	50	47	43	39	35	31	27	23	19	15	11	7	3												
44	52	50	46	42	38	34	30	26	22	18	14	10	6	0											
42	54	52	49	45	41	37	33	29	25	21	17	13	9	3											
40	56	54	52	48	44	40	36	32	28	24	20	16	12	6	0										
38	58	56	54	51	47	43	39	35	31	27	23	19	15	9	3										
36	60	58	56	54	50	46	42	38	34	30	26	22	18	12	6	0									
34	62	60	58	56	53	49	45	41	37	33	29	25	21	15	9	3									
32	64	62	60	58	56	52	48	44	40	36	32	28	24	18	12	6	0								
30	66	64	62	60	58	55	51	47	43	39	35	31	27	21	15	9	3								
28	68	66	64	62	60	58	54	50	46	42	38	34	30	24	18	12	6	0							
26	70	68	66	64	62	60	57	53	49	45	41	37	33	27	21	15	9	3							
24	72	70	68	66	64	62	60	56	52	48	44	40	36	30	24	18	12	6	0						
22	74	72	70	68	66	64	62	59	55	51	47	43	39	33	27	21	15	9	3						
20	76	74	72	70	68	66	64	62	58	54	50	46	42	36	30	24	18	12	6	0					
18	78	76	74	72	70	68	66	64	61	57	53	49	45	39	33	27	21	15	9	3					
16	80	78	76	74	72	70	68	66	64	60	56	52	48	42	36	30	24	18	12	6	0				
14	82	80	78	76	74	72	70	68	66	63	59	55	51	45	39	33	27	21	15	9	3				
12	84	82	80	78	76	74	72	70	68	66	62	58	54	48	42	36	30	24	18	12	6	0			
10	86	84	82	80	78	76	74	72	70	68	65	61	57	51	45	39	33	27	21	15	9	3			
8	88	86	84	82	80	78	76	74	72	70	68	64	60	54	48	42	36	30	24	18	12	6	0		
6	90	88	86	84	82	80	78	76	74	72	70	67	63	57	51	45	39	33	27	21	15	9	3		
4	92	90	88	86	84	82	80	78	76	74	72	70	66	60	54	48	42	36	30	24	18	12	6	0	
2	94	92	90	88	86	84	82	80	78	76	74	72	69	63	57	51	45	39	33	27	21	15	9	3	
0	96	94	92	90	88	86	84	82	80	78	76	74	72	66	60	54	48	42	36	30	24	18	12	6	0

Figure 1. Traffic loading charts like this are used in determining the maximum number of subscribers that can be served by a concentrator.

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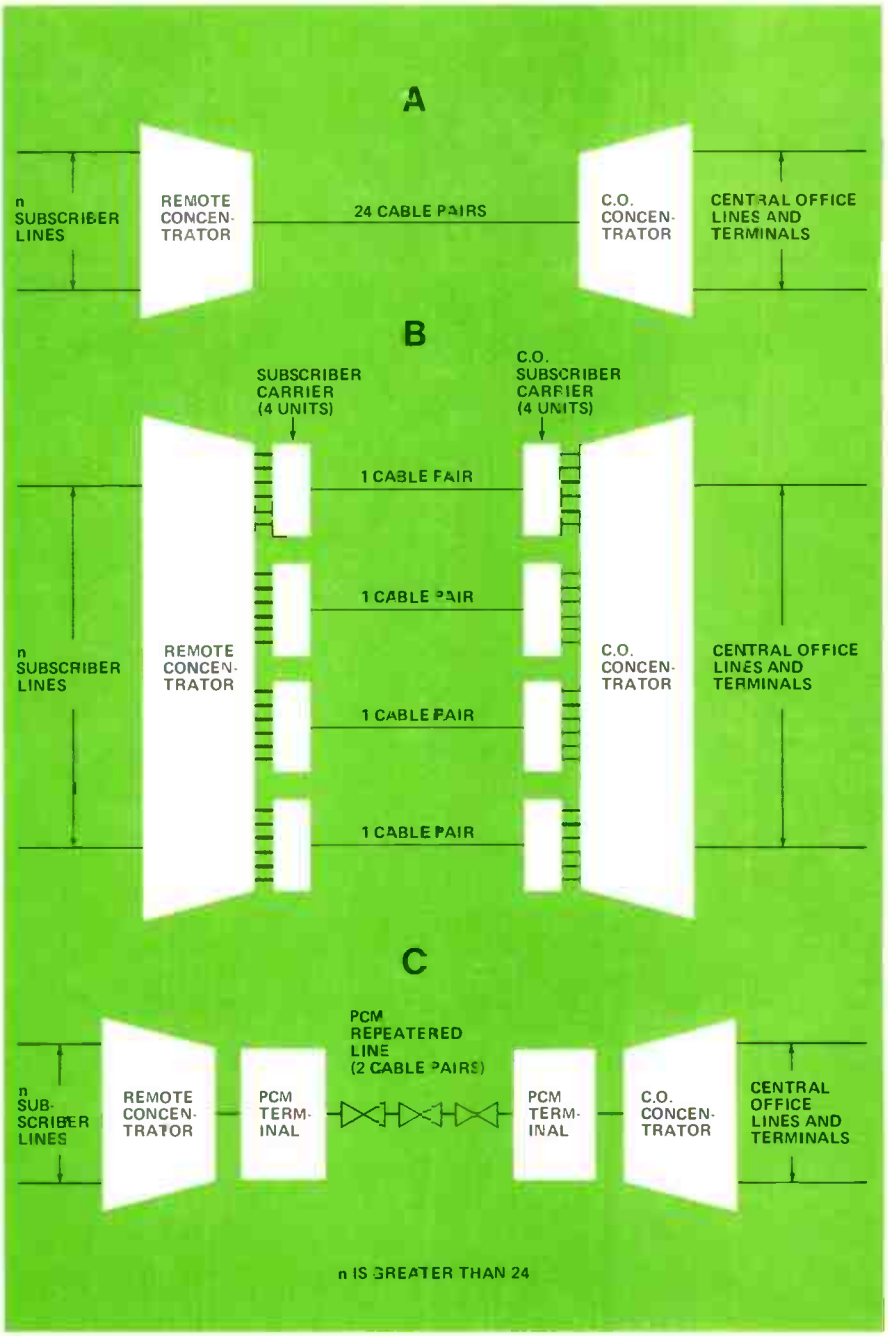

Figure 2. The number of cable pairs required for use with a concentrator varies with the addition of other equipment, such as a subscriber carrier system or a PCM repeatered line.

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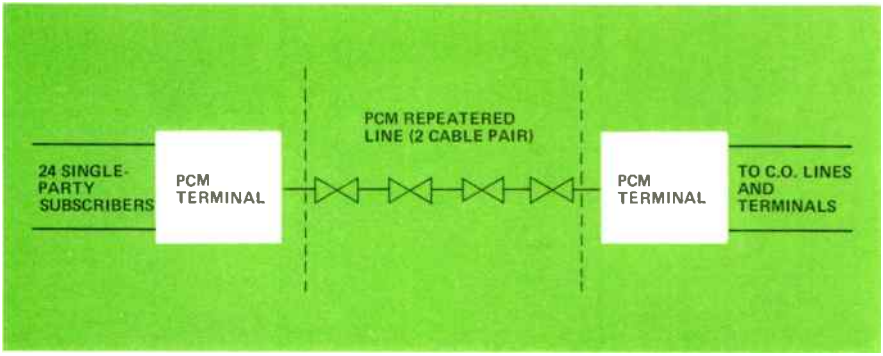

Figure 3. Using PCM terminals by themselves, it is possible to "concentrate" signals on two cable pairs but still provide total access to the central office by all subscribers.

concentrator simultaneously from the central office. If the concentrator is only able to serve one call at a time, a preference and lockout arrangement must be incorporated into the concentrator's design. Where the simultaneous requests originate at the same point, an electromechanical device is sufficient to provide the necessary preference and lockout. This switching device must be capable of recognizing the lines requesting service, determining which is to be served, remembering the identification of the served line, and preventing others waiting to be served from interfering. Concentrator switching is done in segments which simplifies the queuing process but limits the subscriber's access to the C.O. trunks. Instead of having access to all the C.O. trunks, he only has access to a fraction of them.

Some concentrators are also designed to recognize requests for service between two parties served by the same concentrator. Therefore it is not necessary to tie up central office equipment or the trunks to the central office, except for dialing. Once the C.O. terminal recognizes an intracall, the call is connected through at the remote terminal of the concentrator. Once these intratrunks are used up, each subsequent call between any other subscribers using the same concentrator must be connected through the C.O. switching equipment requiring two C.O. trunks. This could quickly degrade service if the area served by the remote concentrator functions as a small community, like a retirement community or a mobile home development where intracalls are frequent. Using a multiplex system, on the other hand, any two parties must be connected through the central office. This ties up the central office equipment, but would not prevent other subscribers at the remote terminals from reaching the central office, since each multiplex subscriber has his own trunk to the central office.

Assuming the called party's phone is not in use, the use of a multiplexer still does not guarantee that all calls will go through because concentration techniques are used throughout the switched telephone network, and have been for many years. It would be too costly and wasteful to have enough "lines" so that all telephone patrons could be talking simultaneously. Sta-

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tistics have shown that even at peak traffic periods, telephone usage is only about 50%. It is partially because of this proven usefulness of concentration techniques within the central office that concentrators were proposed for use outside the central office. In remote locations where there is a sudden influx of subscribers, but where there is not enough growth to warrant a new central office, and where there is not enough capital or time to put in cable pairs for each subscriber, concentrators and multiplexers both seem to offer workable solutions.

Final Choice

The decision to purchase concentrators or multiplexers is based on a variety of factors regardless of whether the information being transmitted is voice or data. There are some applications where the choice is obvious because one or the other, but not both, will do the job required. With voice transmission, the choice usually depends on such subjective things as the quality of service – how often is a call actually blocked when using a concentrator? Statistics are fine for predicting the average traffic loading and the resulting quality of the service, but once installed, who's to say whether the actual use will be anything like the predicted average. With a multiplex system, each subscriber can have his own private line to the central office and the switched network, and statistical traffic loading at the subscriber end is no longer a consideration for the system planner. At this point, cost becomes a major factor, not only in the cost of the equipment but also in the facilities needed for installation, plans for future expansion, necessary routine maintenance, and periodic traffic studies. Both concentrators and multiplexers make more efficient use of cable plant, but in some applications, one will be more efficient and economical than the other.

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U.S. Patent No. 2,806, 088. Granted 10 September 1957.

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