Charpter2
Strowger Switching Systems

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Outline

- Rotary Dial Telephone
- Signaling Tones
- Strowger Switching Components
- Step-by-Step Switching
- Design Parameters
- 100-line Switching System

Introduction

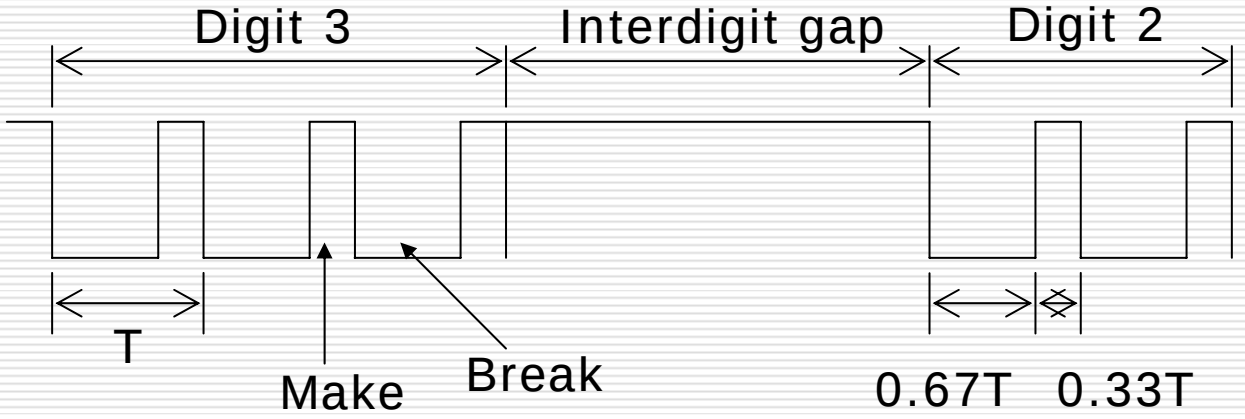
- Strowger Switching System
  - The first automatic Switching System
  - Inventor: Almon B. Strowger
  - Year: 1889
- Advantages
  - Language independent (Standard)
  - High degree of privacy (Security)
  - Fast establishment/release (Efficient)

2.1 Rotary Dial Telephone

- Subscriber Identification
  - How to identify the subscribers?
  - Manual Switching System:
    - Name/Department/Office
  - Automatic Switching System:
    - Numbering Plan
- How to transfer Identity?
  - Pulse dialing
  - Multi-frequency dialing

2.1 Rotary Dial Telephone

- Pulse dialing
  - A train of pulses is used to represent a digit in the subscriber number
  - Successive Digits are distinguished by a pulse (interdigit gap)



2.1 Rotary Dial Telephone

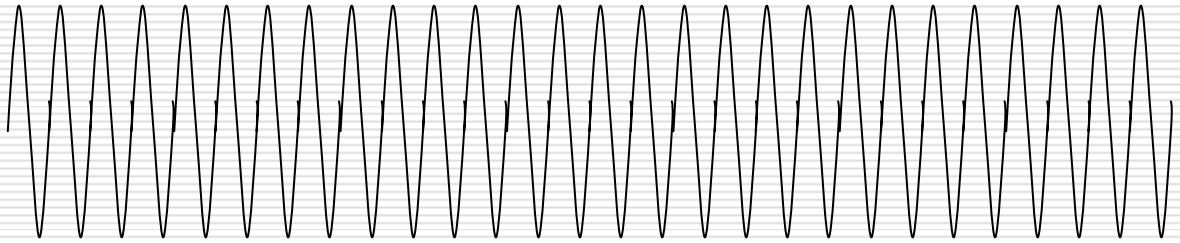
- Pulse dialing

2.2 Signaling Tones

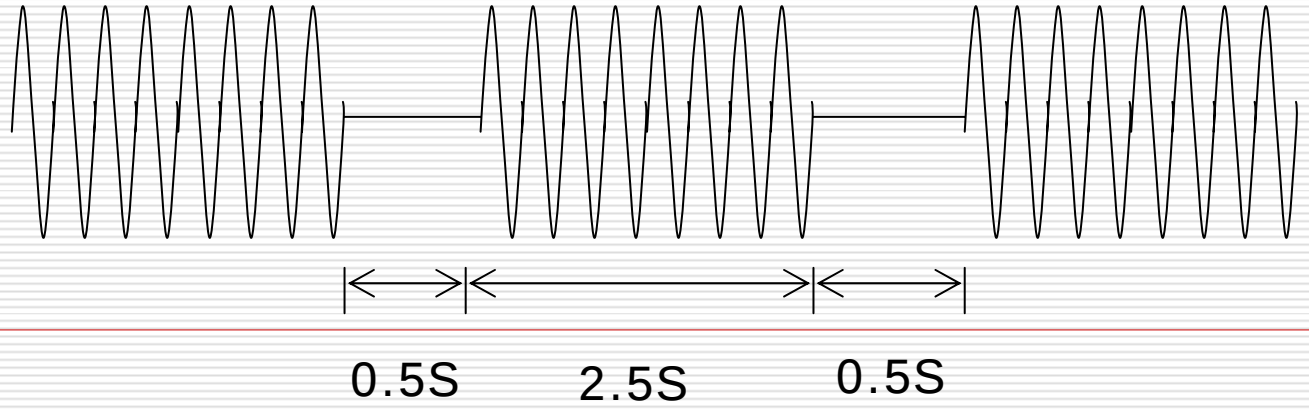
- Functions of Signaling Tones
  - Respond to the calling subscriber to obtain the identification of the called subscriber (Dial Tone)
  - Inform the calling subscriber that the call is being established (Call in Progress Tone)
  - Ring the called party (Ring Tone)
  - Inform the calling subscriber if the called party is busy (Busy Tone)
  - Inform the calling subscriber if the called party is unobtainable for some reason (Number Unobtainable Tone)

2.2 Signaling Tones

- Dial Tone (33Hz/50Hz/400Hz)

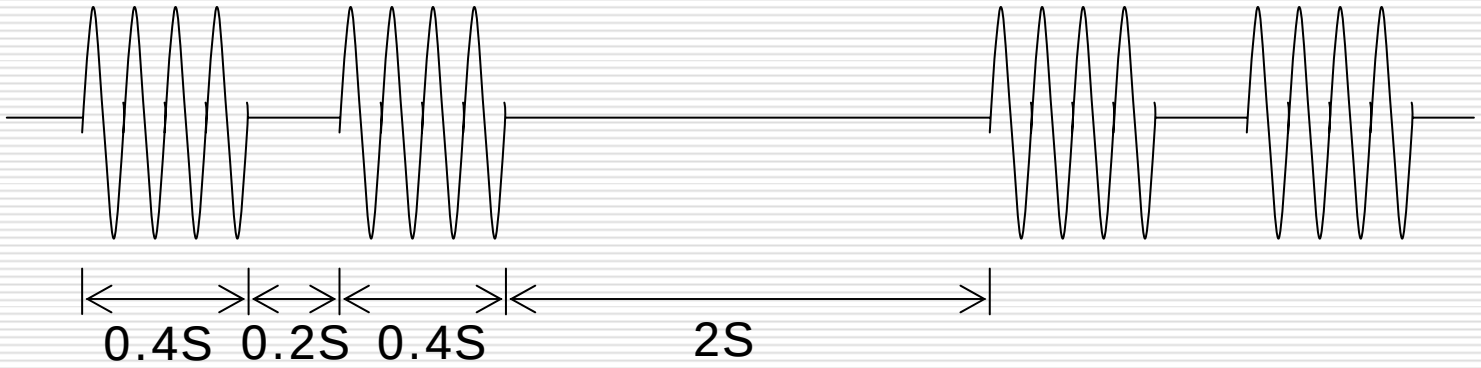


- Call in Progress Tone (400Hz/800Hz)

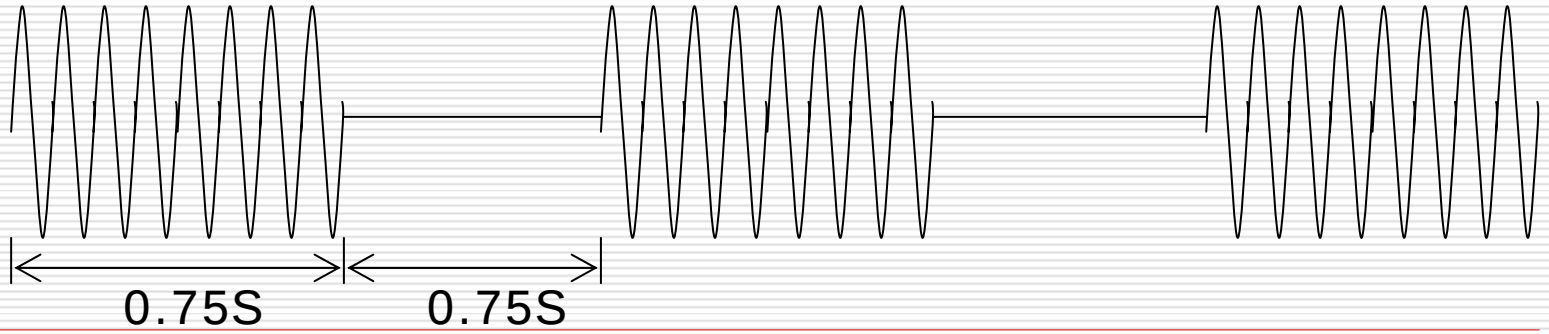


2.2 Signaling Tones

- Ringing Tone (400Hz/133Hz)

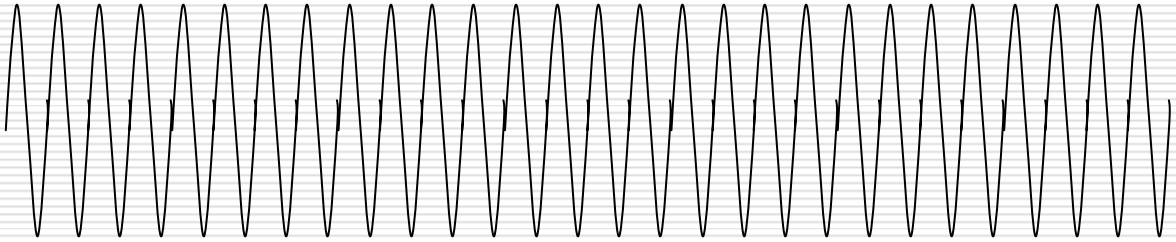


- Busy Tone (400Hz)



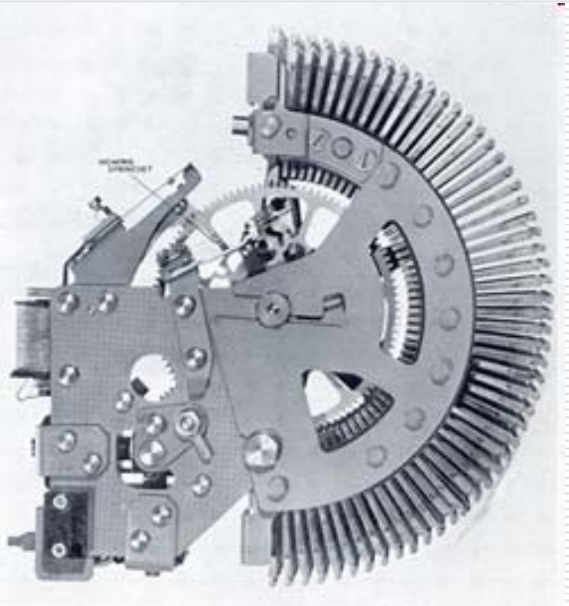
2.2 Signaling Tones

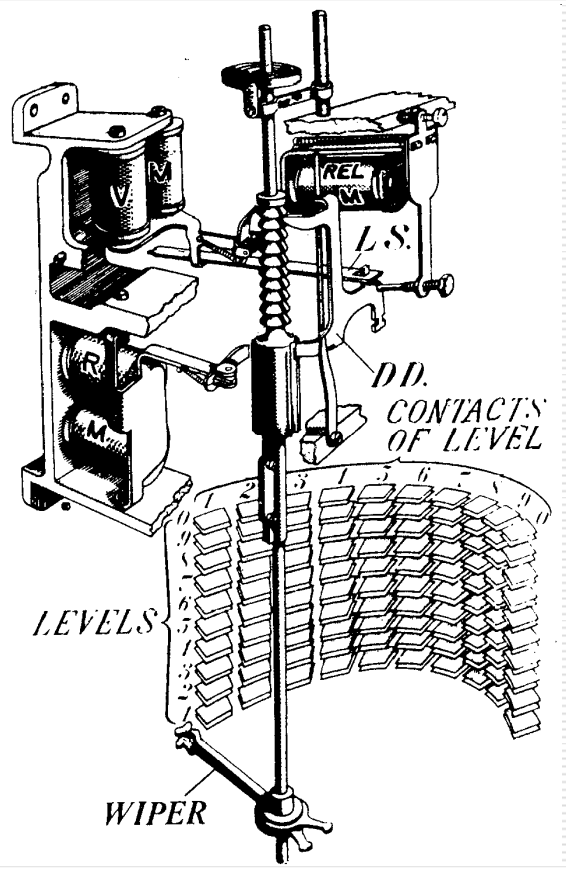
- Number Unobtainable Tone (400Hz)



2.3 Strowger Switching Components

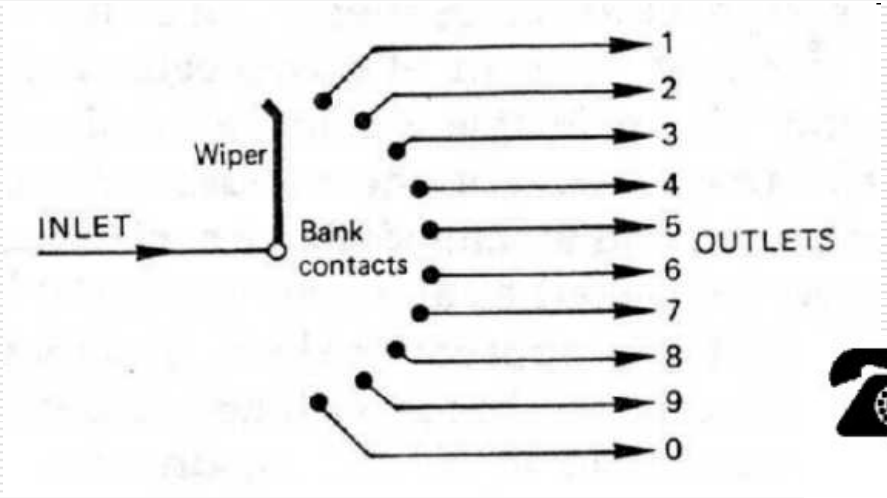
- Two types of selectors
  - Uniselector
  - Two-motion selector

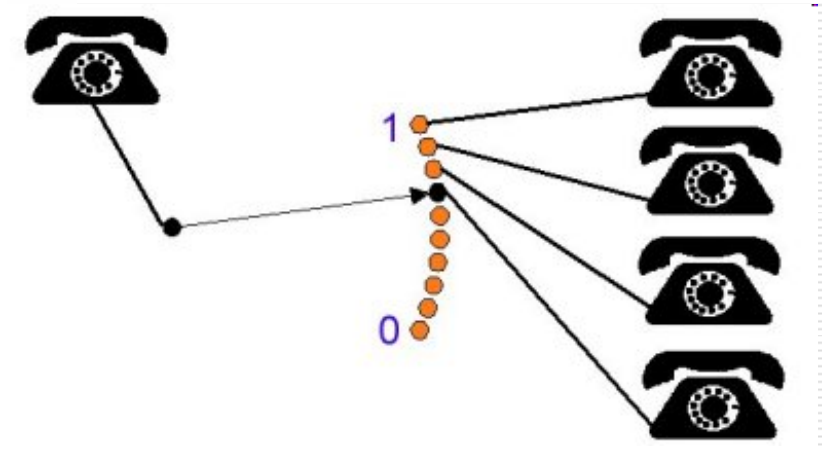




2.3 Strowger Switching Components

- Schematic representation of uniselector





2.3 Strowger Switching Components

- Schematic representation of uniselector

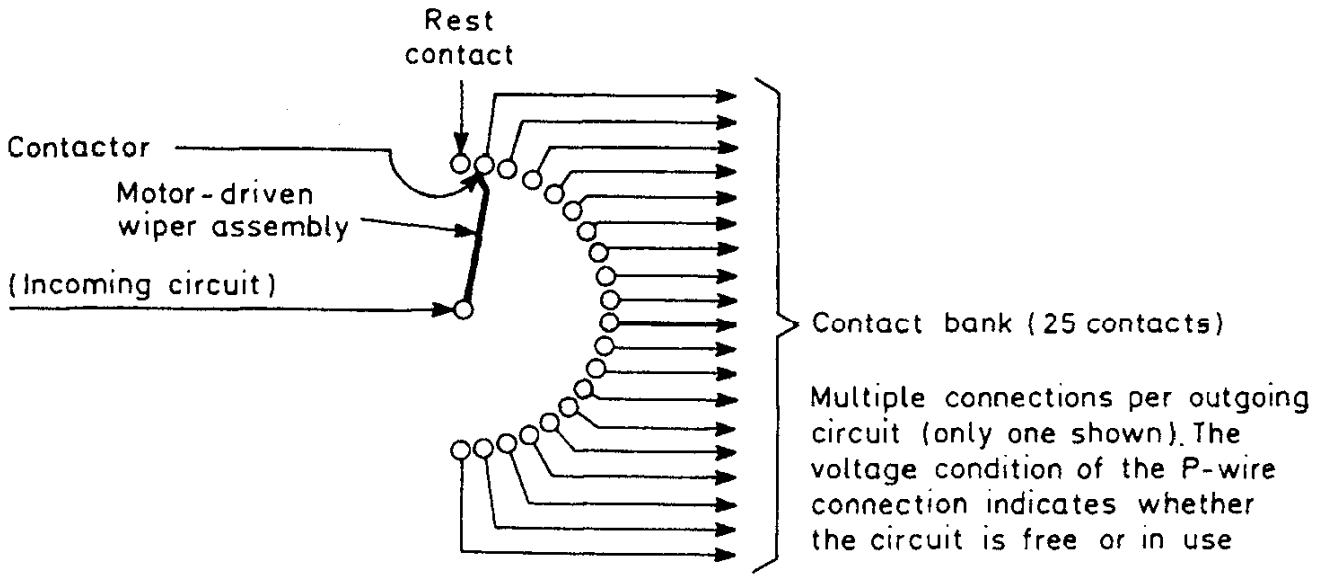
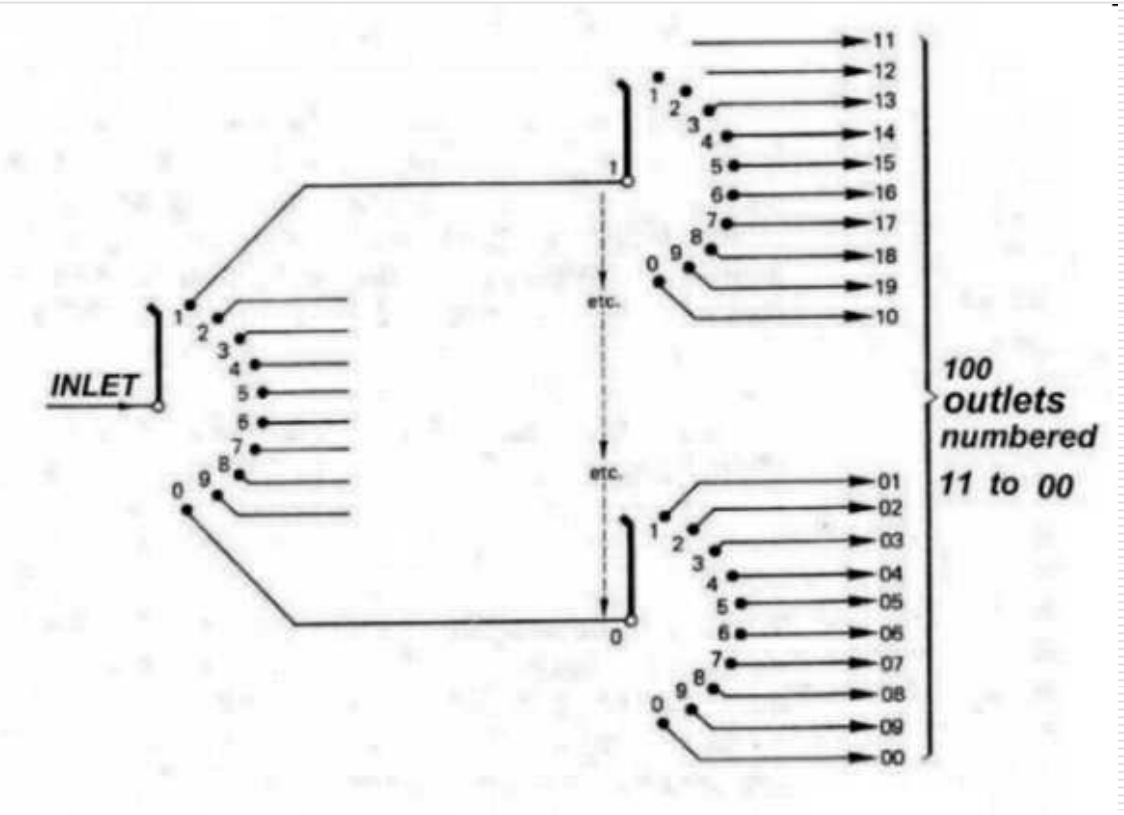


Figure 6.13 A simple uniselector

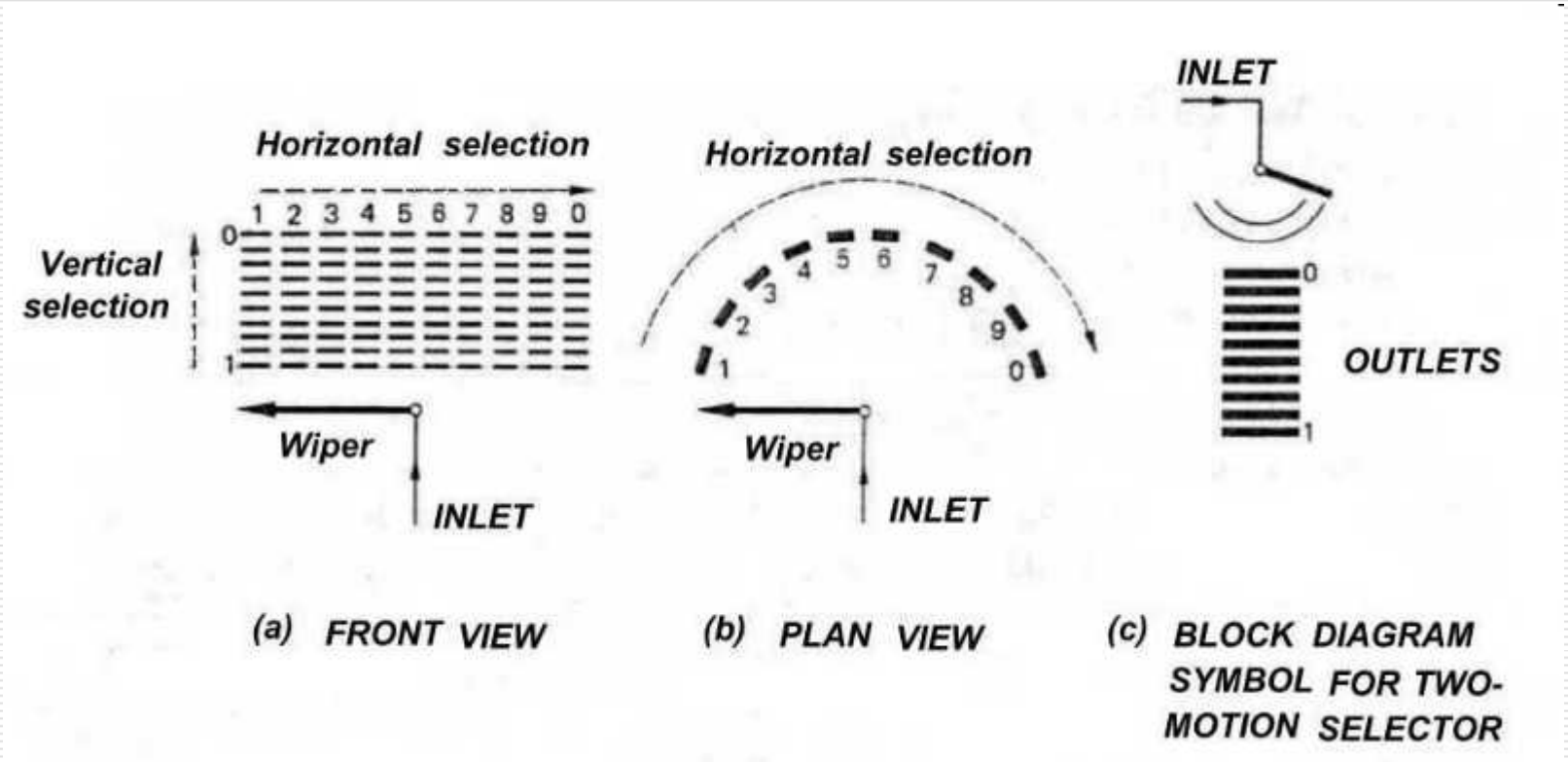
2.3 Strowger Switching Components

- Application of uniselector



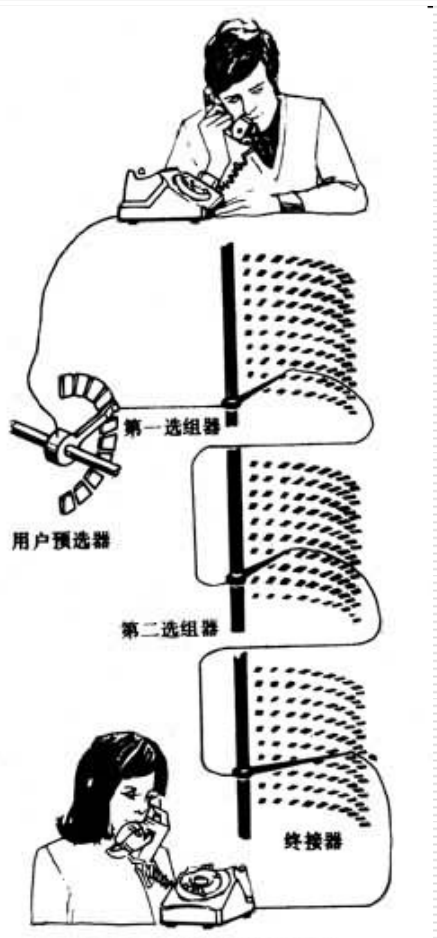
2.3 Strowger Switching Components

- Two-motion selector



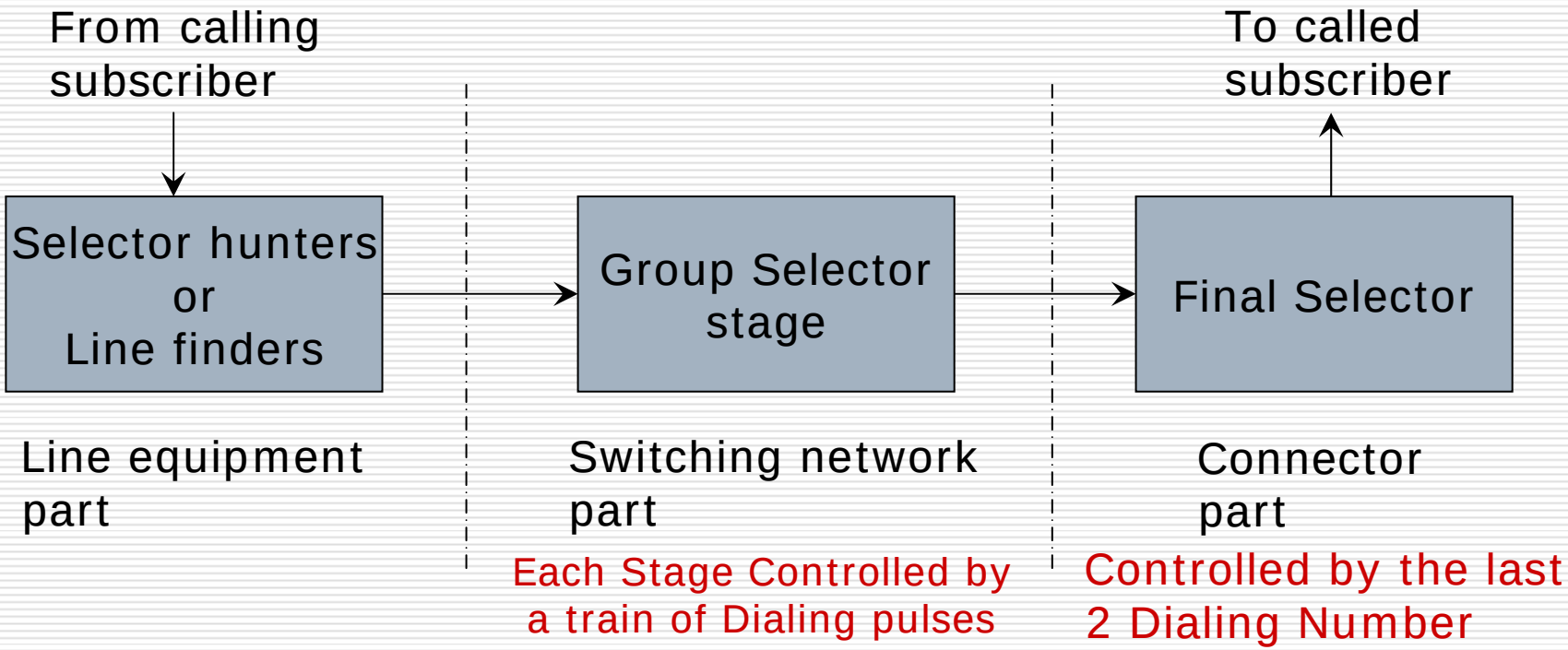
2.4 Step-by-step Switching

- What does “step-by-step” mean?
  - The wiper steps forward by one contact at a time and moves as many contacts as the number of dial pulses received.
- Construction
  - Using uniselector
  - Using two-motion selectors
  - Combination of both



2.4 Step-by-step Switching

- Configuration of a step-by-step switching system



2.4 Step-by-step Switching

- Line equipment part (Preselector stage)
  - Function:
    - Provide access to common switching resources
  - Category:
    - Selector hunters
    - Line finder

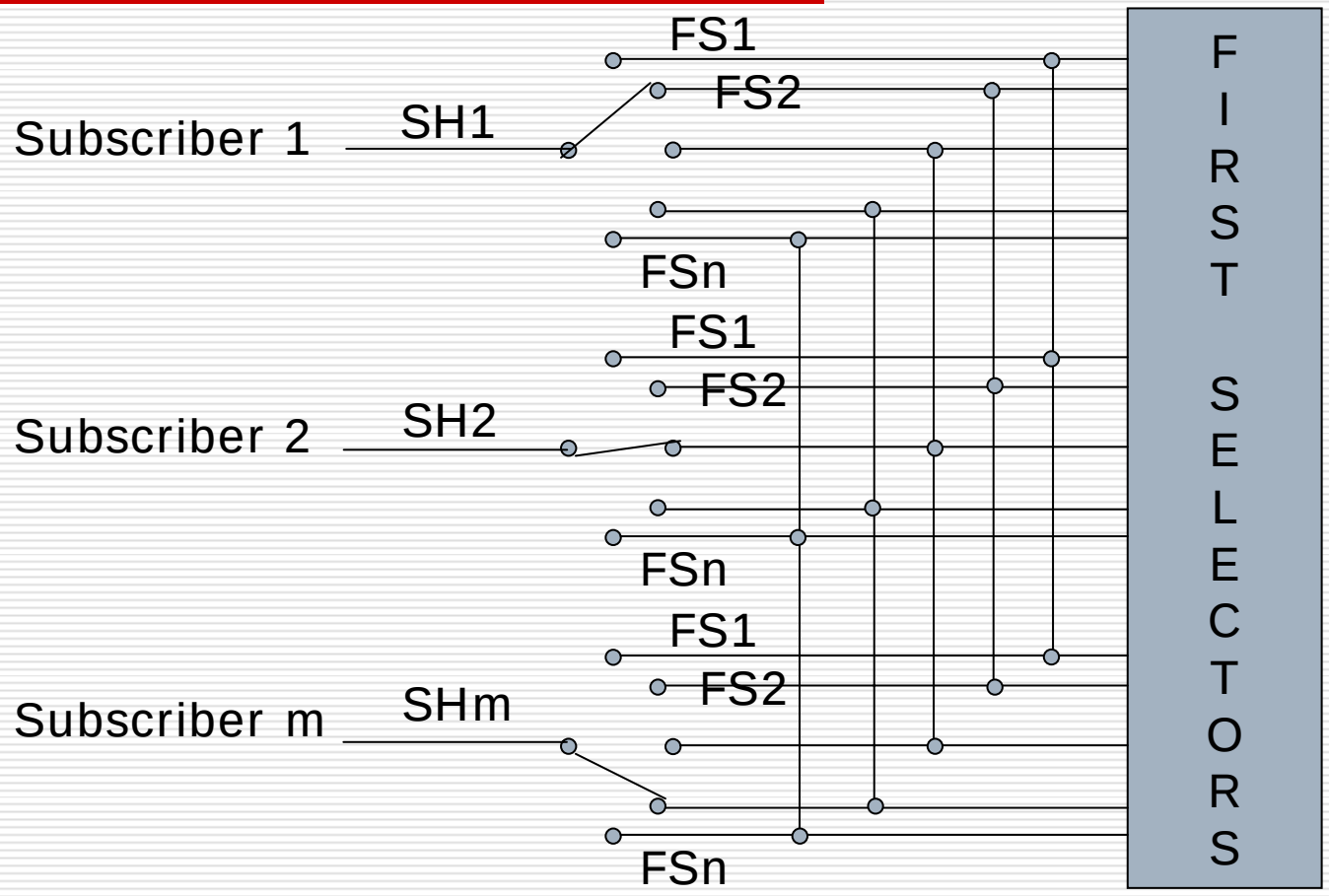
2.4 Step-by-step Switching

- Selector hunter
  - There is one dedicated selector hunter for each subscriber to search and seize a free selector from the switching matrix part.
  - Usually 24-outlet uniselectors are used as selector hunters.

2.4 Step-by-step Switching

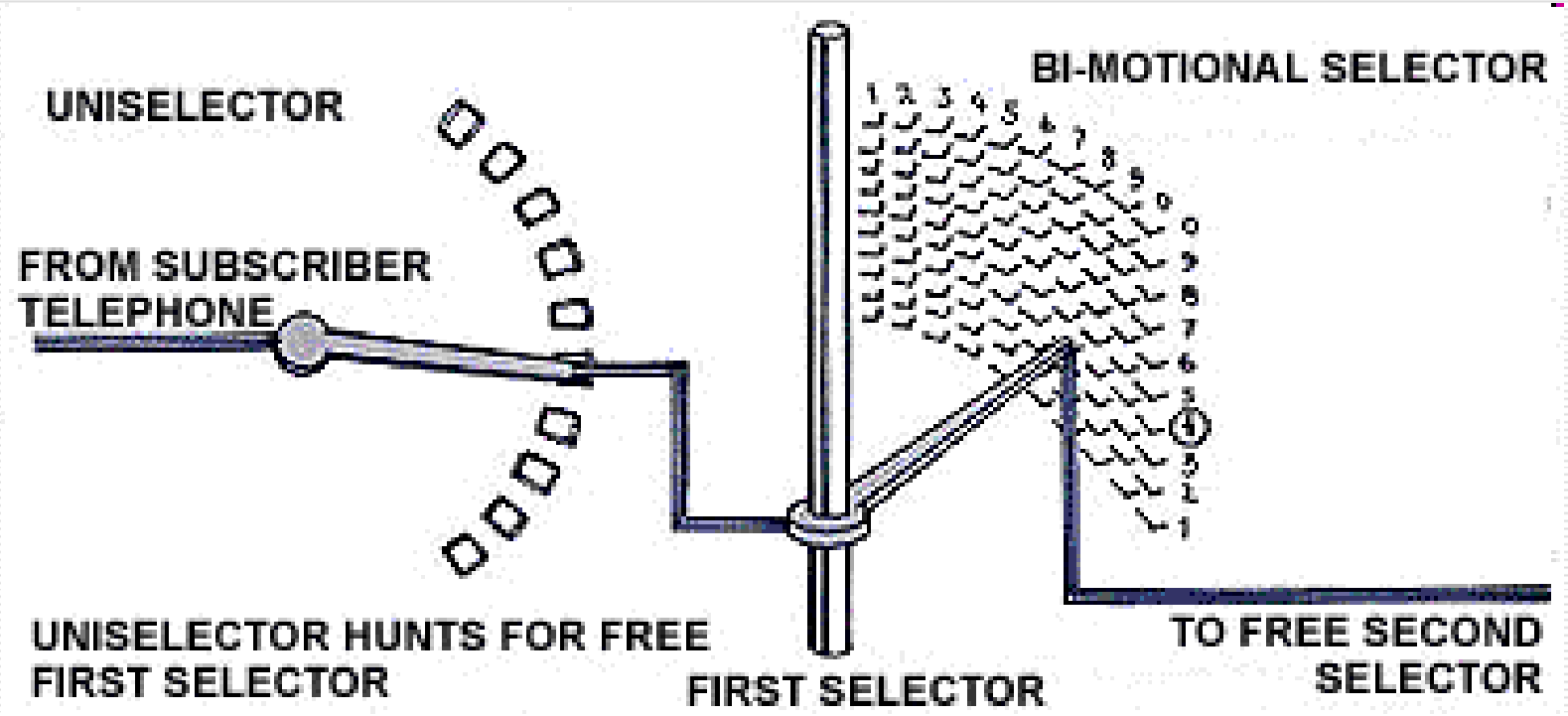
- Line finder
  - Associated with the first set of selectors in switching matrix part, there is one line finder for each selector.
  - Usually built using uniselectors or two-motion selectors.

Selector hunter based access

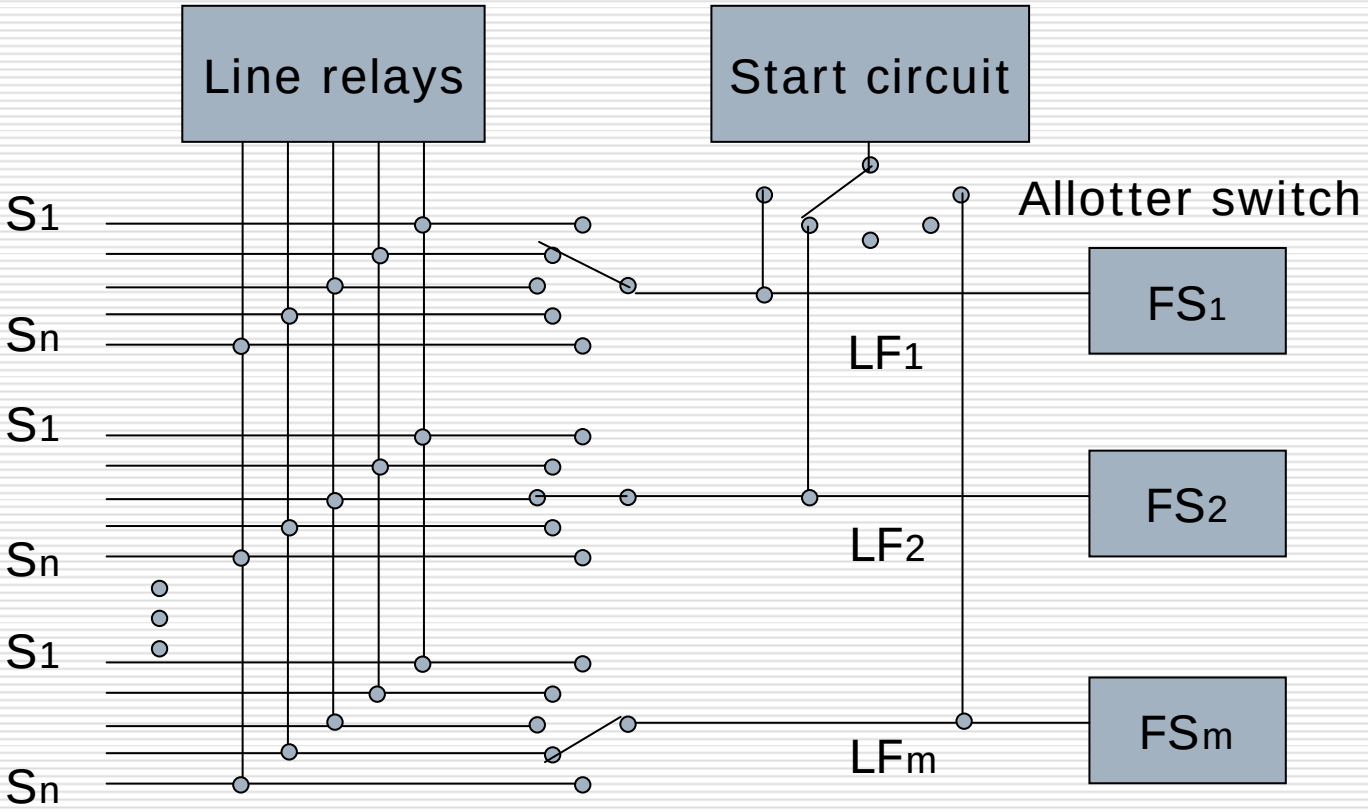


Suitable for large Switches with fairly heavy traffic.

Selector hunter based access

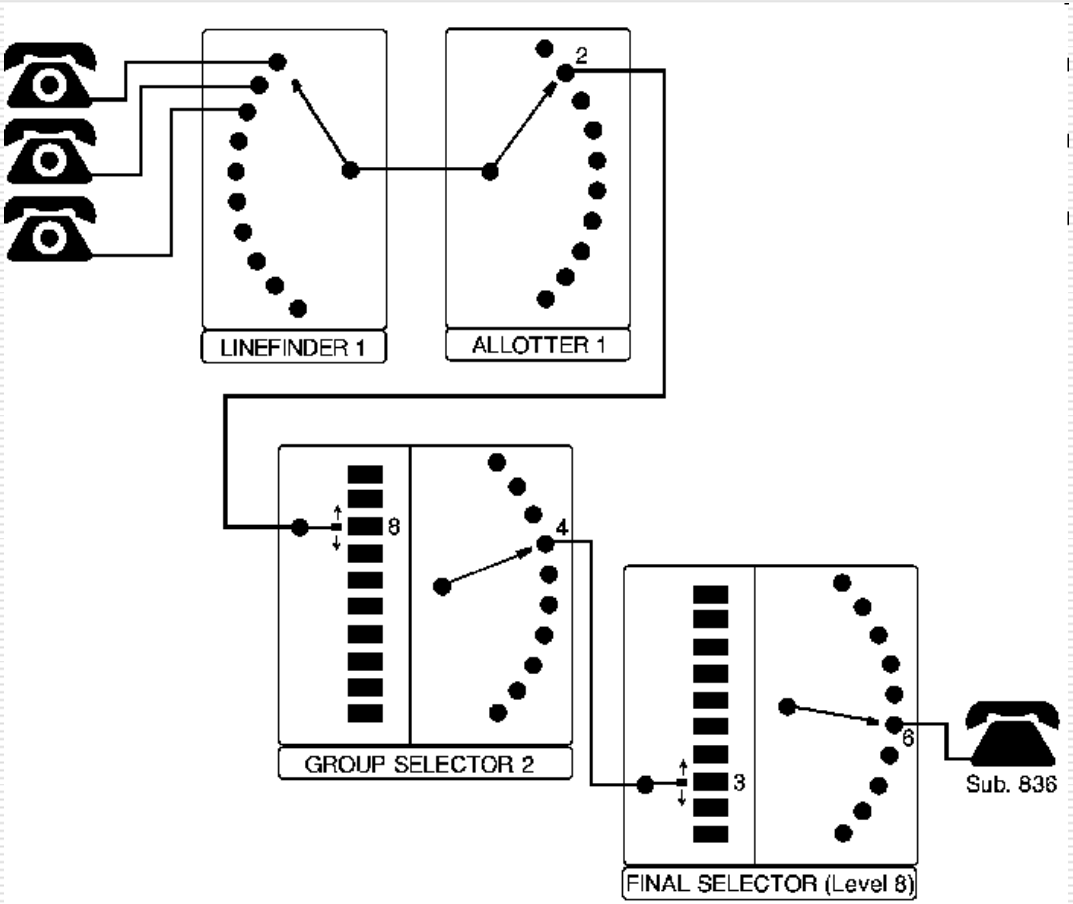


Line finder based access



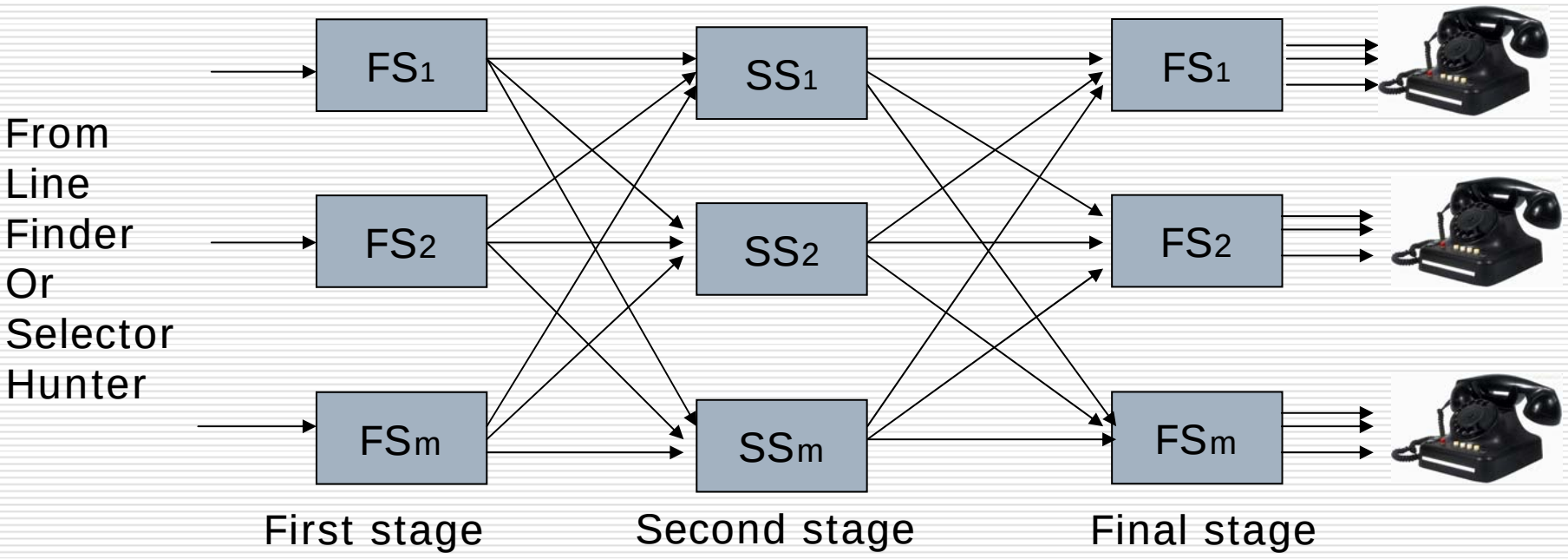
Suitable for small Switches with low traffic.

Line finder based access

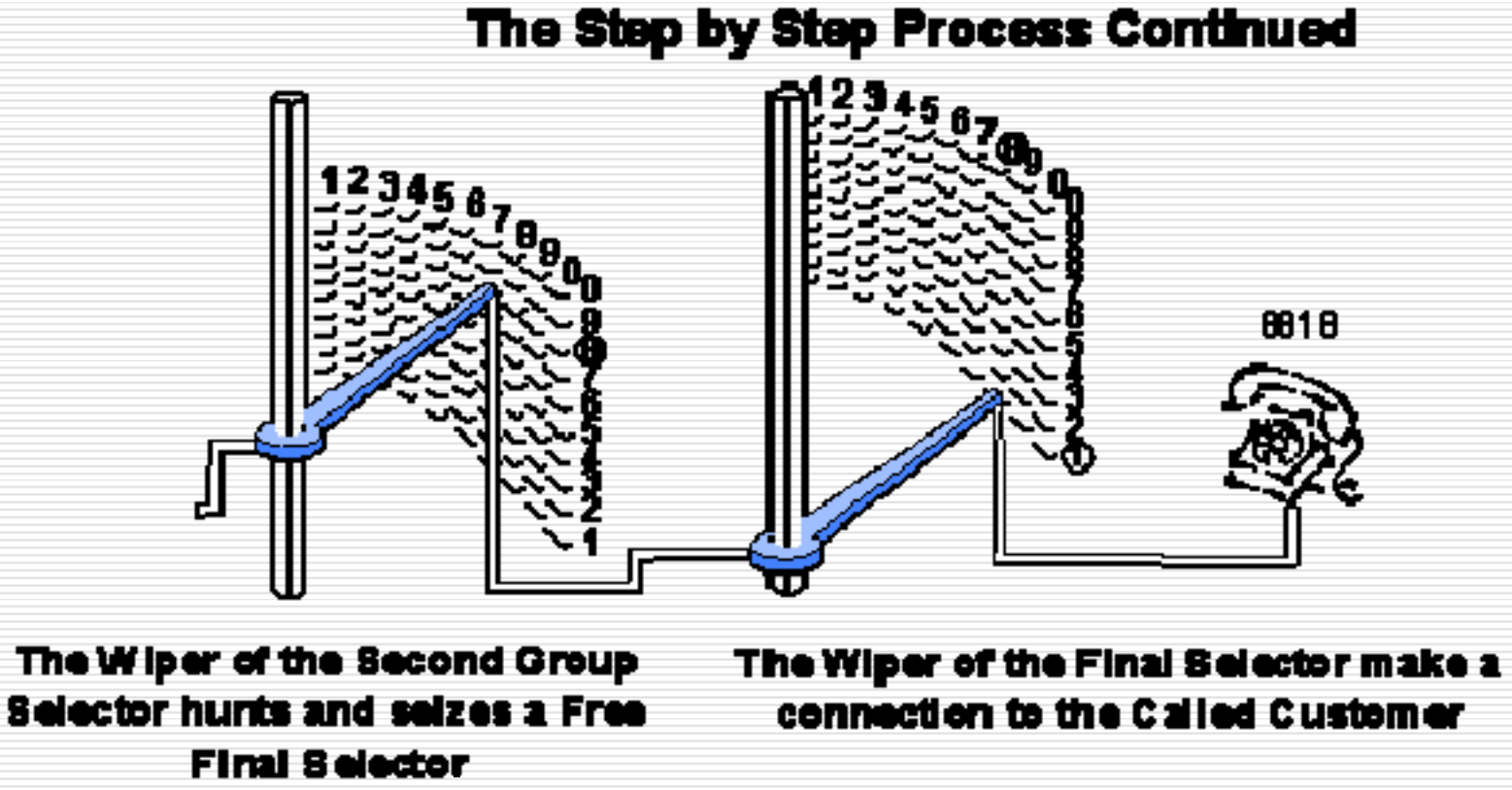


2.4 Step-by-step Switching

- Switching network part (group selector stage + final stage)



Switching network & Connection



2.4 Step-by-step Switching

- Control functions
  - Performed by circuits associated with the selectors.
  - Contact banks:
    - Control and supervisory signals (P-wire/private~)
    - Voice signals (positive & negative wires)
  - Control and supervisory signals are carried from stage to stage by means of contacts in one of the banks.
  - A selector X is said to have seized another selector Y in the next stage when positive, negative and private wires have been connected to those of Y.

2.4 Step-by-step Switching

- Selector control circuits
  - Guarding circuit
  - Impulsing circuit
  - Homing circuit
  - Metering circuit
  - Ring-trip circuit
  - Alarm circuit

Control circuits

- Guarding circuit
  - An essential feature of all the selectors
  - Making the selector busy as soon as it is seized.
  - The guarding condition remains set as long as the call is not terminated.
  - The guarding condition is indicated by an earth on the P-wire.

Control circuits

- Impulsing circuit
  - An essential part of all those selectors which have to respond to dialing pulses, i.e. group and final selectors
  - The circuit is designed around 3 relays:
    - 1 Fast acting: respond to dialing pulses and pass them to P-wire.
    - 2 slow acting:
      - Maintaining guarding conditions
      - Recognizing the end of a pulse train

Control circuits

- Homing circuit
  - All the selectors need homing circuit.
  - Function: At the end of a conversation, release all the selectors and make them return to their home positions.

Control circuits

- Metering circuit
  - A special feature of the final selectors.
  - Function: Register a call against the calling party as soon as the called party answers. The circuit drives a meter containing counting mechanism.

Control circuits

- Ring-trip circuit
  - A part of the final selectors.
  - Function: Control the ringing current to the called party and the ringing tone to the calling party.
  - Both the ringing current and the ringing tone are cut off by the ring-trip circuit as soon as the called party answers the call.

Control circuits

- Alarm circuit
  - Provide visual and audible indications of any fault or undesirable condition creeping into the selector circuits.
  - Three types of faults detected:
    - Off-hook condition: short circuit in the subscriber line or the subscriber not having replaced his handset on the hook.
    - Called-subscriber-held: the handset of called-subscriber is not replaced properly.
    - Release held: sense the failure of a selector to return to home position.

2.5 Design Parameters

- Design alternatives
  - Entirely on the basis of uniselectors
  - Entirely on the basis of two-motion selectors
  - Combination of both
- Architecture of a switching network
  - Switching elements
  - Associated circuits

2.5 Design Parameters

- Costs associated
  - Cost of switching network
  - Cost of control subsystem
  - Cost of common hardware elements

2.5 Design Parameters

- Design parameters
  - Number of subscriber lines, N
  - Total number of switching elements, S
  - Cost of the switching system, C

$$C = S \times C_s + C_c + C_{ch}$$

    - C_s – cost per switching element
    - C_c – cost of the common control subsystem
    - C_{ch} – cost of the common hardware
  - Switching capacity, SC

2.5 Design Parameters

- Traffic handling capacity, *TC*

  $$TC = 2(SC)/N$$

- Equipment utilization factor, *EUF*

  EUF = (number of SE in operation) / (total number of SE)

  SE stands for Switching Element

- Number of switching stages, *K*
- Average switching time per stage, T_{st}
- Call setup time, $T_s = KT_{st} + T_0$
- Cost capacity index, $CCI = SC / (C/N)$

Concept: blocking probability.

2.6 100-line Switching System

- A 100-line switching system can serve up to 100 subscribers.
- Assumption
  - The cost of a uniselector is one.
  - The cost of a two-motion selector is two.
- Five different design alternatives are provided.

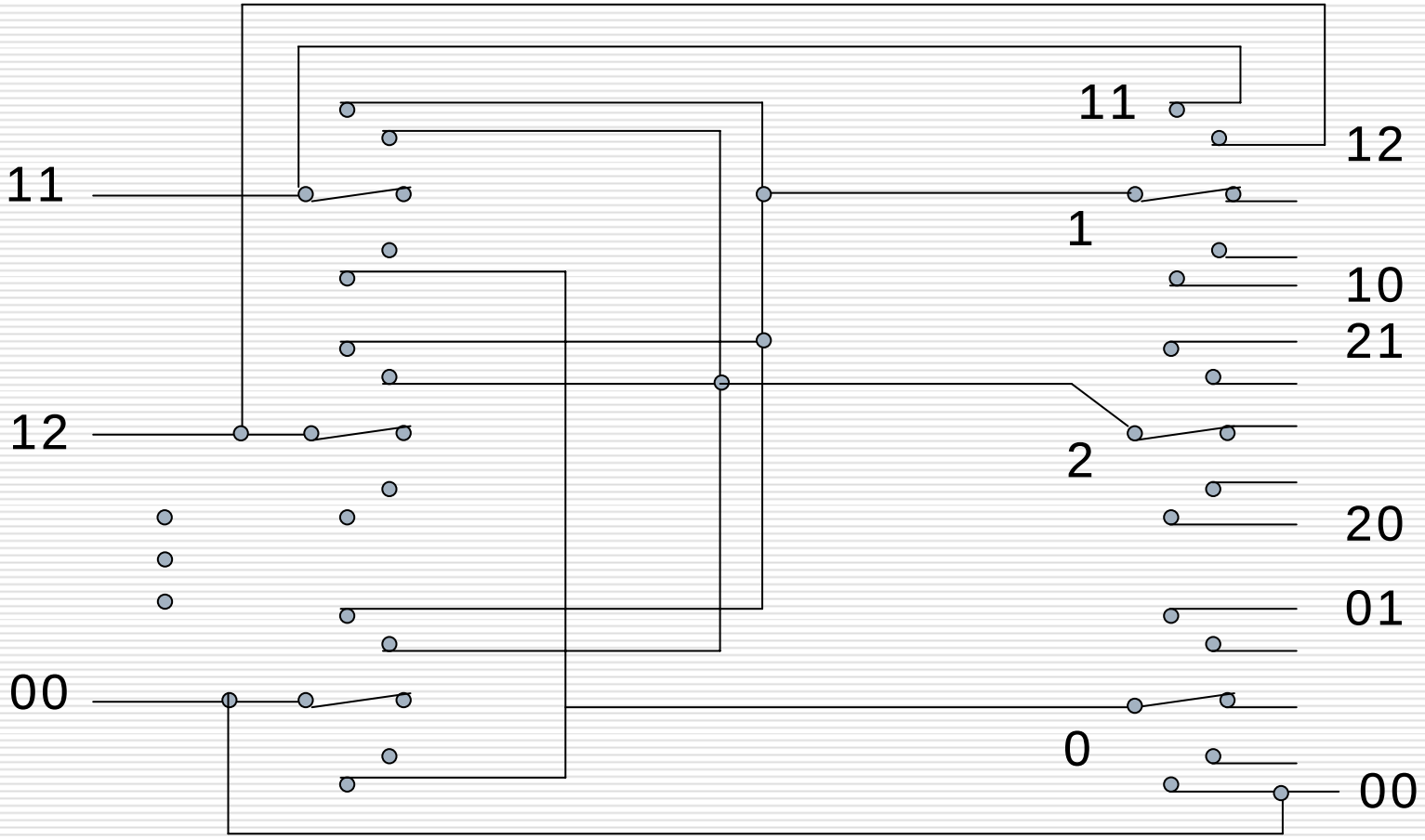
2.6.1 design 1

- 100-line switch using uniselectors
  - Using10-outlet uniselectors
  - Architecture: two stages
  - Dialing number：2 digits (00~99)
  - First stage:
    - 100 uniselectors, one for each subscriber.
    - Responds to the first dialing digit.

2.6.1 design 1

- The second stage:
  - 10 or more uniselectors, the outlets are folded back to the corresponding inlets via suitable control circuitry.
  - Responds to the second dialing digit.
- 10 calls can be established simultaneously.

100-line switch using uniselectors



100-line switch using uniselectors

- Design parameters
  - S=110; SC=10;K=2;TC=0.2
  - EUF=0.18; C=110; CCI=9.09
- Blocking scenarios
  - 10 calls are in progress and the 11th one arrives;
  - A call is in progress and another call arrives, which is destined for a number in the same decade.

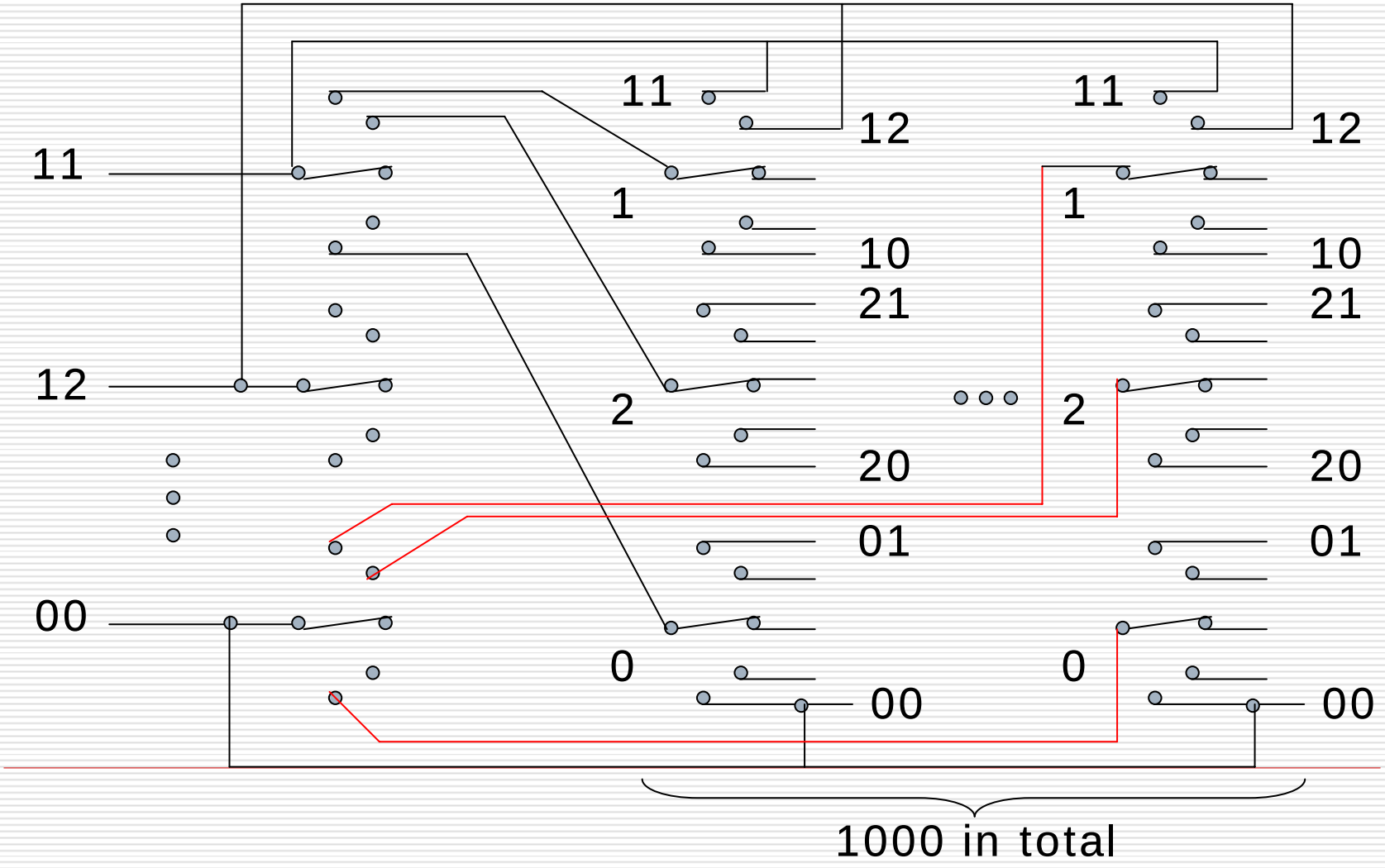
2.6.2 design 2

- Using10-outlet uniselectors
  - Architecture: two stages, totally 1100 uniselectors
  - Dialing number：2 digits (00~99)
  - First stage:
    - 100 uniselectors, one for each subscriber.
    - Responds to the first dialing digit.

2.6.2 design 2

- The second stage:
  - 100 uniselectors for each subscriber.
  - Responds to the second dialing digit.
- 50 calls can be established simutaneously

100-line switch using uniselectors



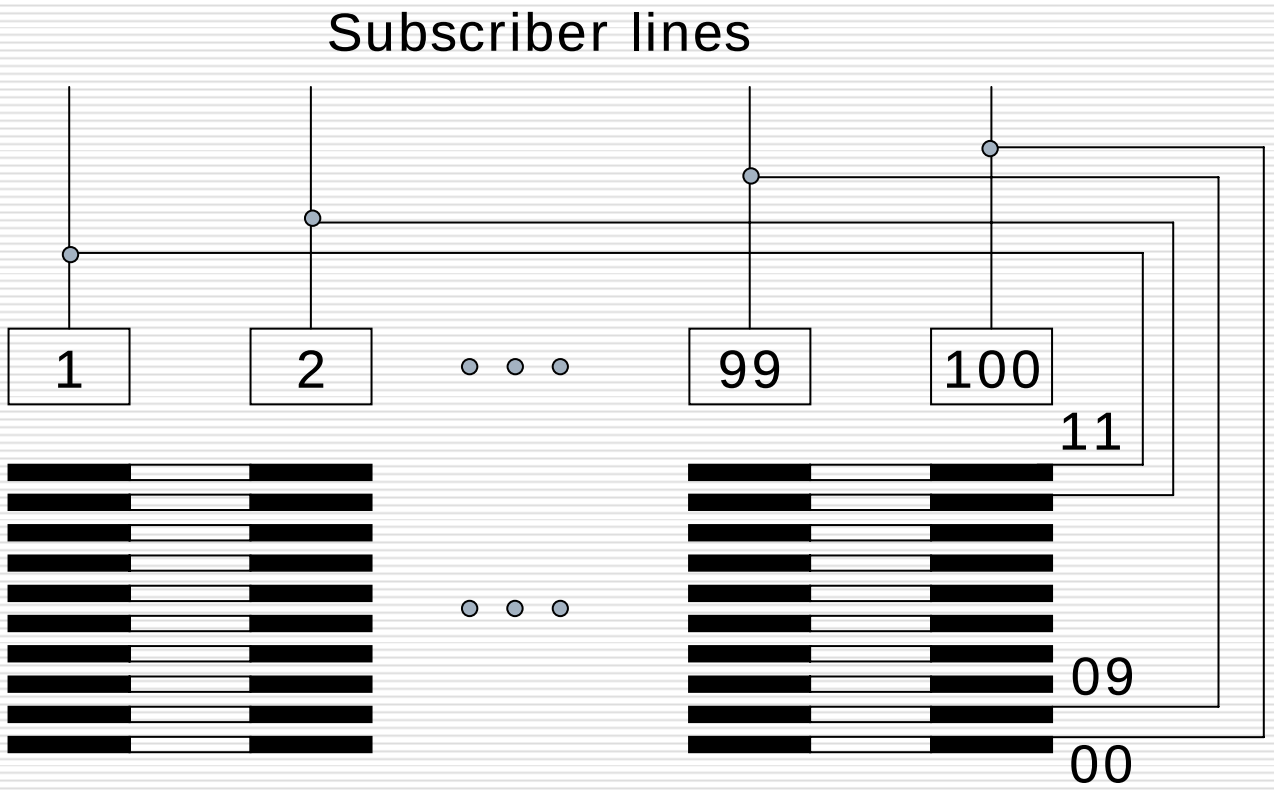
100-line switch using uniselectors

- Design parameters
  - S=1100; SC=50;K=2;TC=1
  - EUF=0.09; C=1100; CCI=4.54
- No Blocking Network

2.6.3 design 3

- 100-line exchange with one two-motion selector per subscriber
  - A 100-outlet two-motion selector per subscriber
  - A subscriber is assigned a number in range 00~99
  - The corresponding outlets in all 100 selectors are commoned and fold back to the corresponding inlets
  - The two-motion selector used to establish a call is dependent upon the initiator of the call.

100-line exchange with one two-motion selector per subscriber



100-line exchange with one two-motion selector per subscriber

- Design parameters
  - S=100; SC=50;K=1;TC=1
  - EUF=0.5; C=200; CCI=25
- No Blocking Network

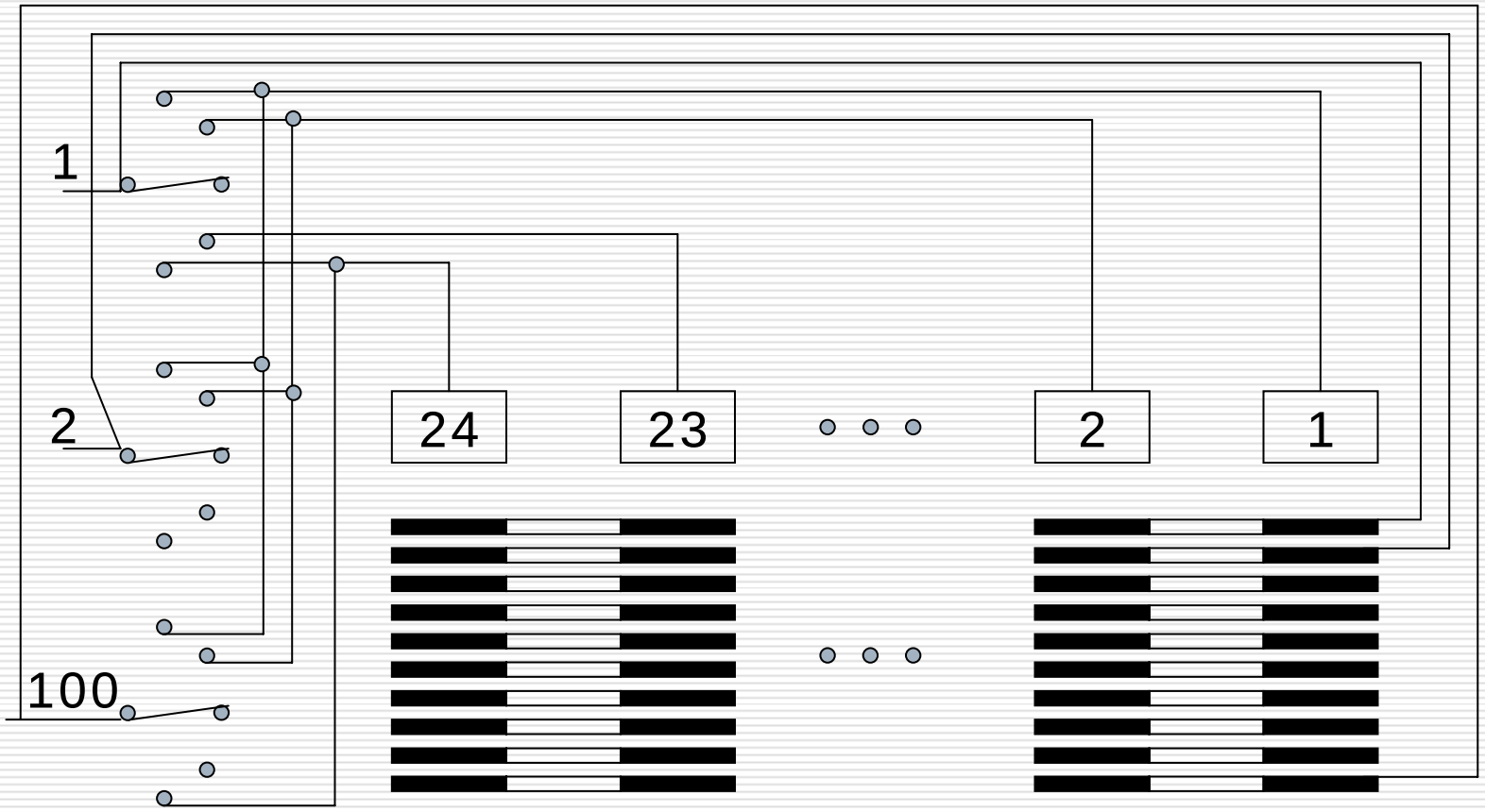
2.6.4 design 4

- 100-line exchange with selector finder
  - 24 two-motion selectors shared by 100 users
  - Corresponding outlets of all 24 selectors are commoned and feed back to inlets
  - Assumption: the average peak-hour traffic is 24 simultaneous calls

2.6.4 design 4

- Sharing mechanism:
  - One 24 outlets selector hunter per subscriber
  - The corresponding outlets of all the selector hunters are commoned and thus, all subscribers have access to all the two-motion selectors.

100-line exchange with selector finder



100-line exchange with selector finder

- Design parameters
  - S=100 uniselectors + 24 two-motion selectors
  - SC=24; K=2; TC=0.48;
  - EUF=0.58; C=148; CCI=16.2
  - Blocking probability depends on traffic characteristics
- Cost effective

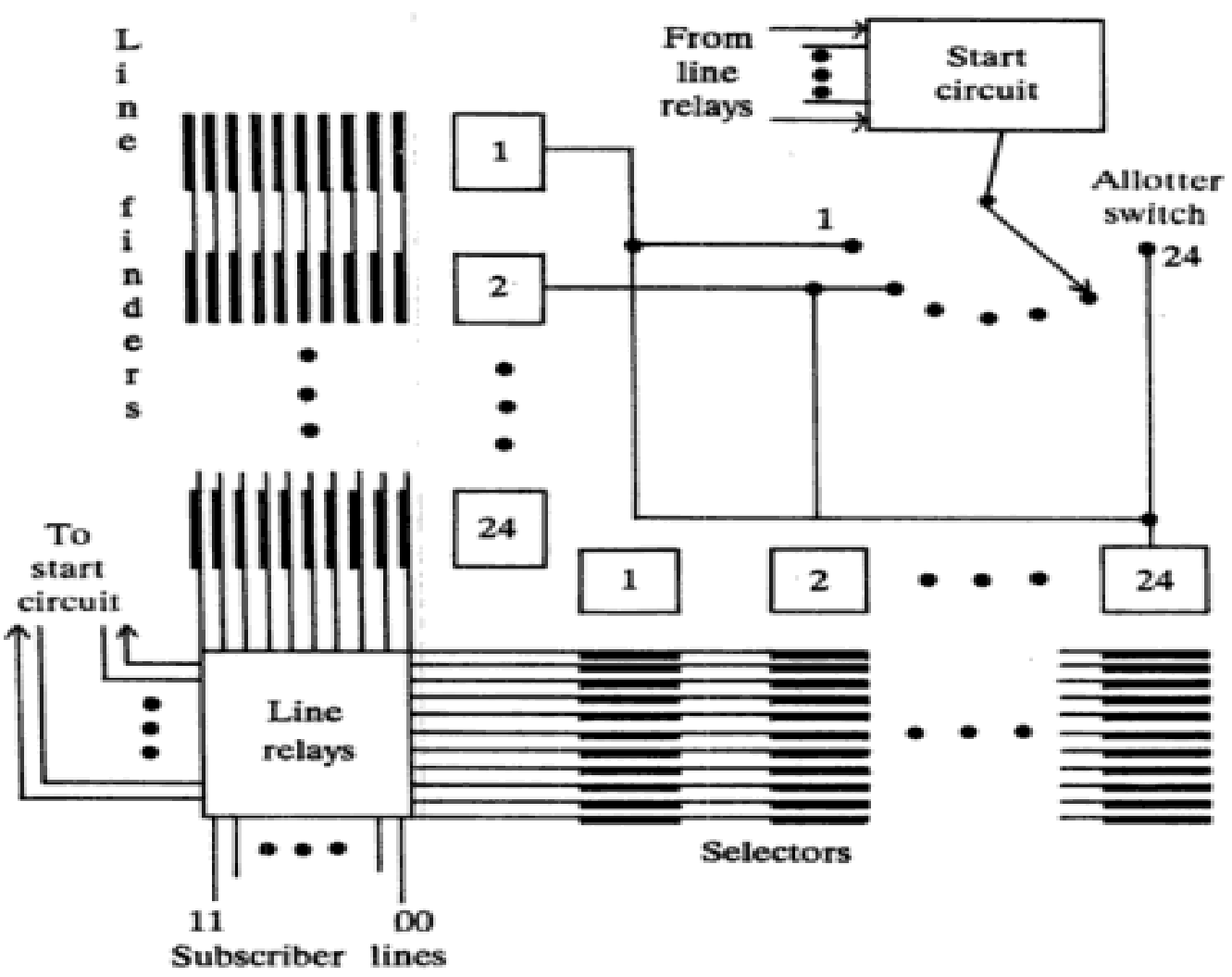
2.6.5 design 5

- 100-line exchange with two-motion finders
  - 24 two-motion selectors shared by 100 users
  - Corresponding outlets of all 24 selectors are commoned
  - Assumption: the average peak-hour traffic is 24 simultaneous calls

2.6.5 design 5

- Sharing mechanism:
  - One line finder per two-motion selector
  - The corresponding outlets of all line finders are commoned and thus, all subscribers have access to all the two-motion selectors.

2.6.5 design 5


Line finders
From line relays
Start circuit
Allotter switch
1
2
24
1
2
24
1
2
24
To start circuit
Line relays
Selectors
11 Subscriber lines
00

2.6.5 design 5

- Design parameters
  - $S=48$
  - $SC=24$; $K=1$; $TC=0.48$;
  - $EUF=1$; $C=96$; $CCI=25$
  - Blocking probability depends on traffic characteristics
- Cost effective

2.7 1000-line Blocking Exchange

- A blocking design is considered.
- Subscribers are identified by a three-digit number ranging from 000 to 999.
- Selectors used:
  - Preselector/Group Selector/Final Selector

2.7 1000-line Blocking Exchange

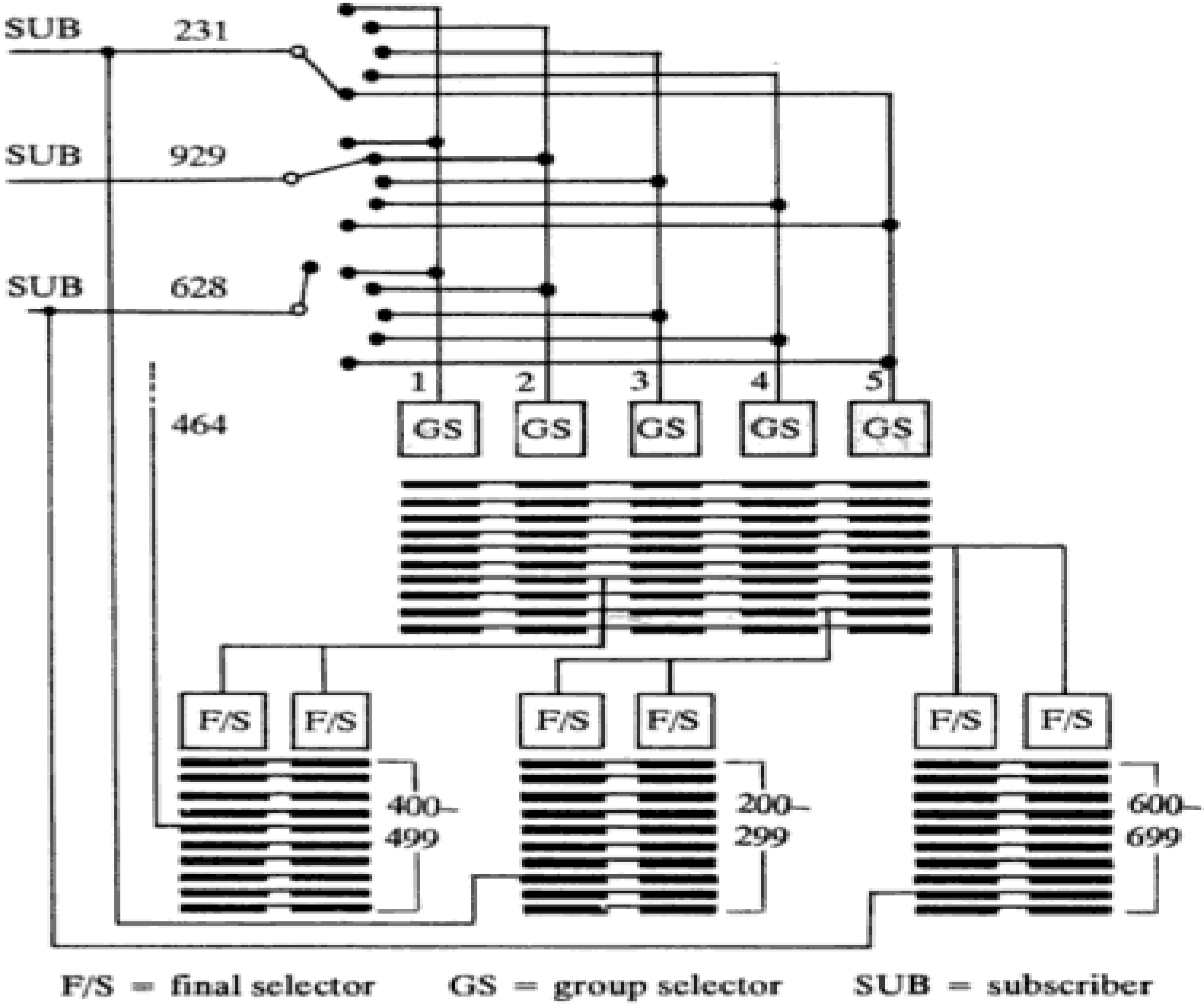
- One uniselector for each subscriber to hunt a free Group selector (GS) in preselection stage.
  - Each uniselector has 24 outlets.
  - Each outlet of the uniselector is connected to a specific GS.
  - Corresponding outlets of all uniselectors are commoned to share GS.

2.7 1000-line Blocking Exchange

- A number of two-motion selectors (GS) are employed for common use.
  - Each outlet is connected to a specific final selector (F/S).
  - Outlets of each vertical level of all GS's support a group of 100 subscribers.
  - Controlled by the first digit.
  - The number of GS can be changed to obtain good quality of services.

2.7 1000-line Blocking Exchange

- A number of two-motion selectors are employed as F/S.
  - All F/S's are divided into 10 groups.
  - Each group are connected to a specific level of GS and commoned in outlets to support 100 subsrcibers.
  - The number of F/S can be changed to support more simultaneous calls.


SUB
231
SUB
929
SUB
628
464
1
2
3
4
5
GS
GS
GS
GS
GS
F/S
F/S
F/S
F/S
F/S
F/S
400–
499
200–
299
600–
699
F/S = final selector
GS = group selector
SUB = subscriber

2.7 1000-line Blocking Exchange

- Example 1
  - In a 1000-line exchange, the number range 000-299 is allotted to business subscribers. Forty percent of these subscribers in each group of 100 are active during peak hours.
  - The number range 300-999 is allotted to domestic connections. Ten percent of the domestic subscribers are active in each group at any time.
  - Estimate the total number of final selectors required.???

2.7 1000-line Blocking Exchange

- Solution
  - Number of simultaneous calls for business subscriber groups is equal to 20 per group;
  - Number of simultaneous calls for domestic subscriber groups is 5 per group.
  - Total number of final selectors required is: $3X20+7X5=95$

2.7 1000-line Blocking Exchange

- Example 2
  - In example 1,
    - The probability of more than 40 percent business customers being active is 0.01.
    - The probability of more than 10 percent of the domestic customers being active is 0.05.
    - Assume that switching stages other than final selector stage are designed to be nonblocking.
  - Estimate the blocking probability of the exchange. ???

2.7 1000-line Blocking Exchange

- Solution
  - The exchange appears blocking in two cases:
    - A business customer is blocked when more than 40 percent business customers are active. The corresponding probability is 0.01.
    - A domestic customer is blocked when more than 10 percent domestic customers are active. The corresponding probability is 0.05.
  - As a result, the blocking probability is

$$P_B = 0.05 + 0.01 = 0.06$$

Assignments

- Exercise 2
- Exercise 15