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Reynolds et al.

[11] **3,760,360**

[45] **Sept. 18, 1973**

[54] **MATRIX SWITCH**

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[73] Assignee: **E-Systems Incorporated,** Dallas, Tex.

[22] Filed: **Nov. 1, 1971**

[21] Appl. No.: **194,261**

[52] **U.S. Cl.**..... **340/166 R,** 340/24, 340/225

[51] **Int. Cl.**..... **H04q 9/10,** G08b 5/00, G08g 1/12

[58] **Field of Search**..... 340/166, 324 R, 378 A, 340/225; 178/18; 343/5 MM; 235/61.6 A

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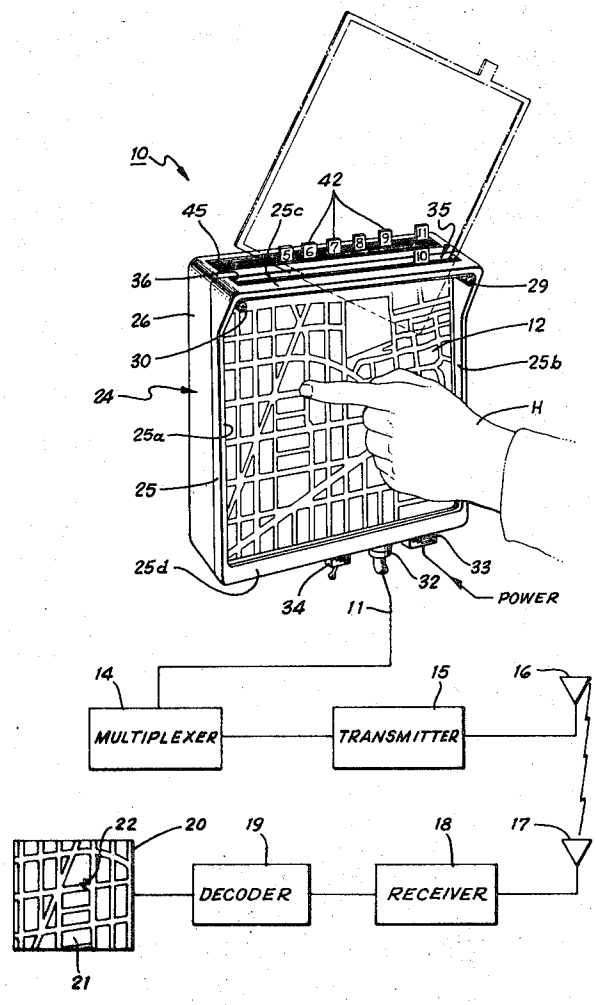
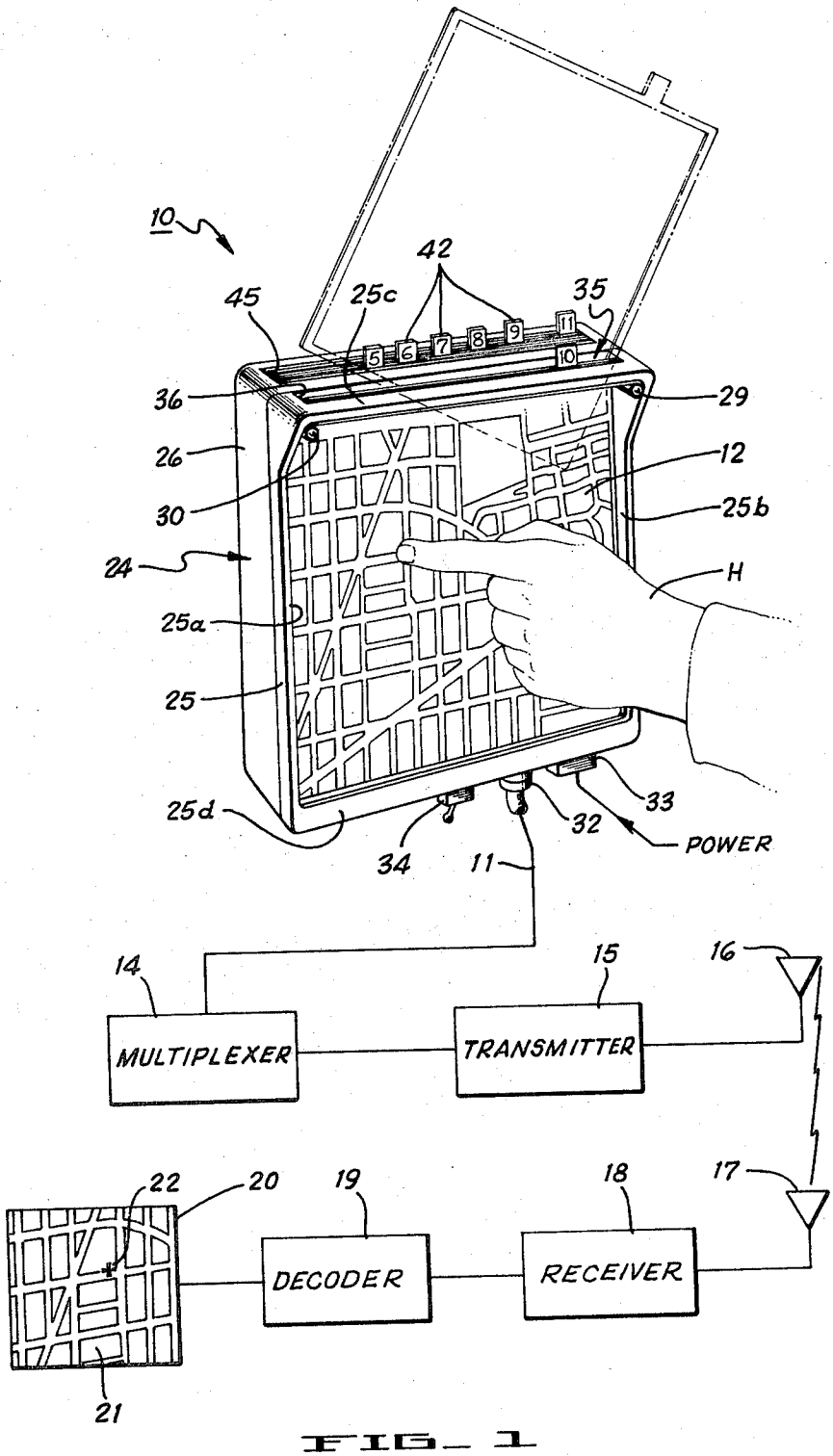
Attorney—Norman J. O'Malley et al.

[57] **ABSTRACT**

A finger-pressure actuated matrix switch assembly includes a map overlay and generates a binary coded signal corresponding to the coordinates of the point of application of pressure to the map. The assembly comprises a housing with a slot for positioning a replaceable map card in operative position and a storage chamber for a plurality of such map cards. Each of the map cards is edge-notched with a unique code identifying that card, and switches supported on the housing are actuated by these notches when a map card is inserted into its operative position to generate a binary electrical signal corresponding to that code. The matrix or grid is formed by orthogonally related sets of printed conductors on stacked boards spaced apart by resilient strip separators formed directly on one of the boards. Logic circuitry for converting the coordinates of contacting conductors into binary digits is carried on a single pluggable board detachably connected to the matrix boards for quick replacement to facilitate maintenance and repair.

9 Claims, 5 Drawing Figures

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42
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25b
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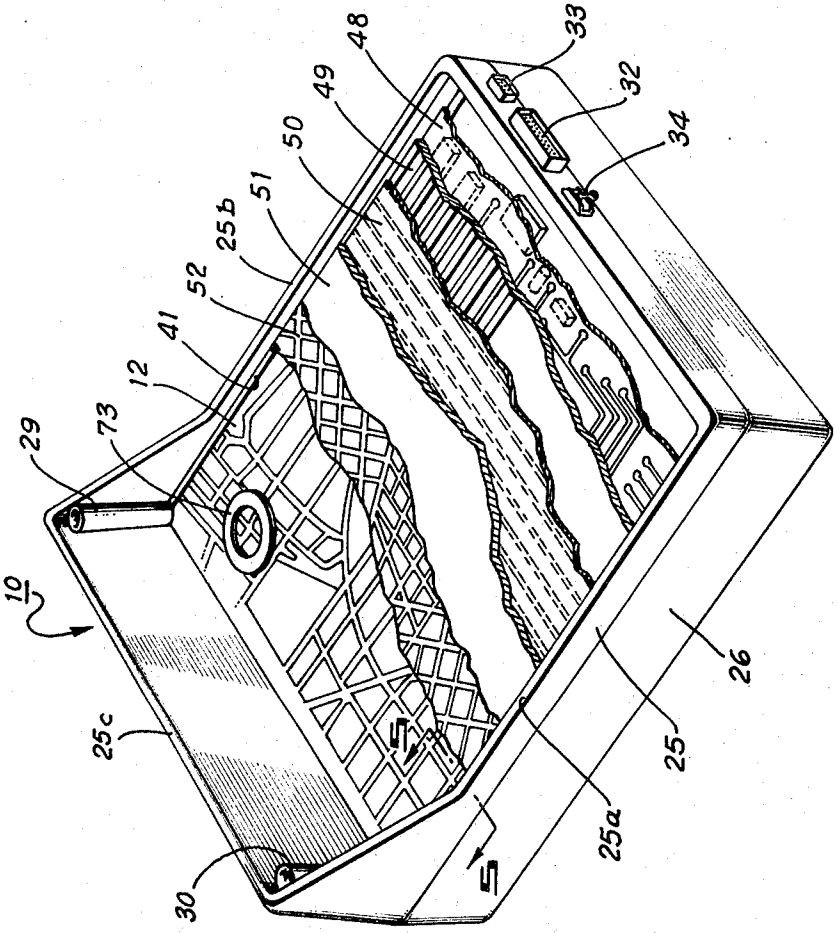
H
25a
25
25d
34
11
32
33
POWER
14
15
16
MULTIPLEXER
TRANSMITTER
22
20
19
18
17
DECODER
RECEIVER
21

FIG. 1


48
33
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34
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25b
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41
12
73
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25c
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25a
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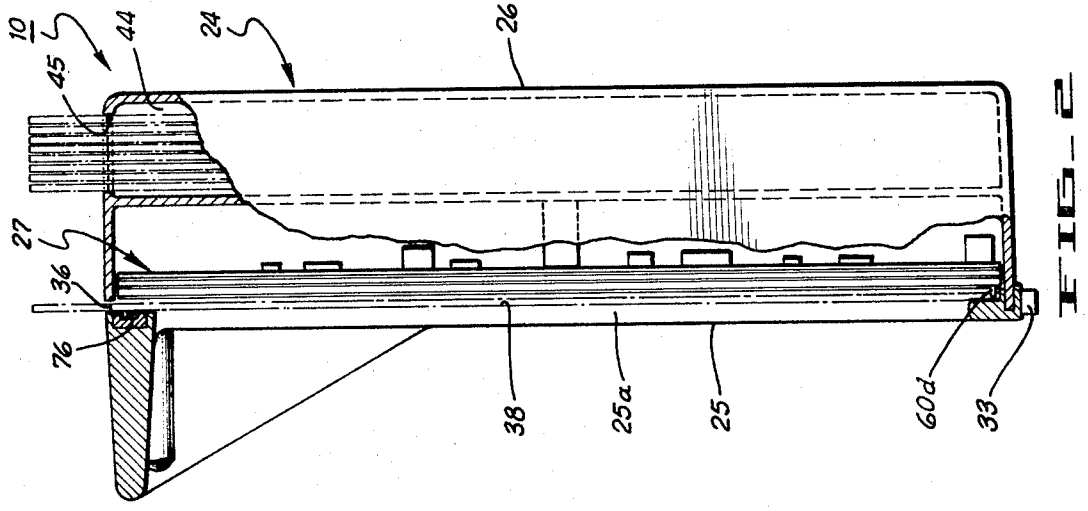
26

FIG. 3


10
44
24
26
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27
36
76
38
25a
25
60d
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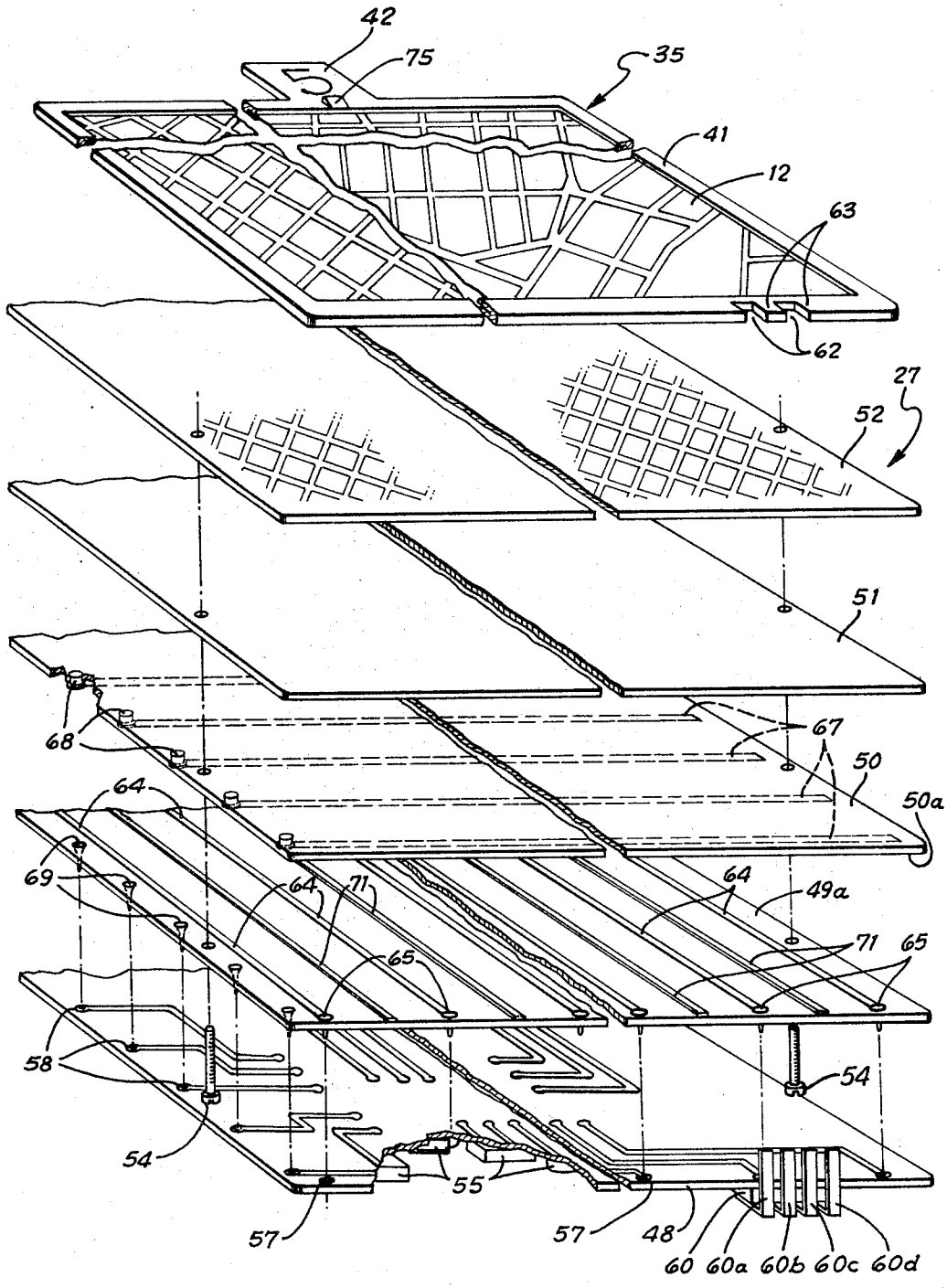
FIG. 2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63
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71
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60a
60b
60c
60d

FIG_4

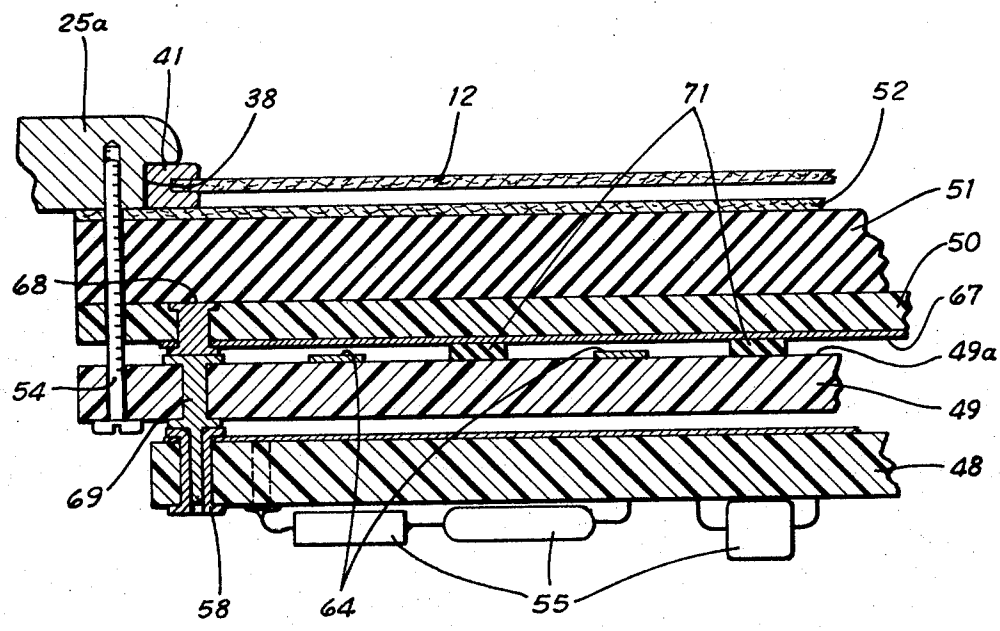

FIG. 5

MATRIX SWITCH

BACKGROUND OF THE INVENTION

This invention relates to matrix switches and more particularly to an improved pressure-actuated matrix switch assembly for generating electrical signals identifying the coordinates of the point of pressure on the assembly. Such a switch is useful in police and other vehicles for giving a remote station the location of the vehicle.

The police department of a medium size city having a population of 300,000 or more may have as many as thirty police patrol cars on duty at one time. In order to maintain a current and accurate record of the location of all patrol cars, the officer in each patrol car periodically calls the dispatcher to report his location. Each of these messages is verbally acknowledged by the dispatcher who then manually enters the information on a status board. Operation in this mode crowds the available communication channels with routine messages and prevents the dispatcher from addressing more important tasks requiring his attention. One of the prior art techniques proposed for automatically accomplishing this function comprises a transmitter in each car periodically transmitting at a unique characteristic frequency and several fixed receiving antennas at different stations around the city which triangulate on received signals to fix the location of the vehicle. Such systems are complex and expensive.

An improved vehicle location system utilizing a finger-actuated matrix switch in the vehicle to generate a binary coded signal for transmission over the radio network to the dispatcher is described in copending application Ser. No. 287,631 of Kent Penwarden. A key element in such a locator system is the pressure-responsive matrix switch assembly which generates a binary signal corresponding to the position of a selected pressure point on a street map overlaying the switch. This invention is directed to an improved construction of such a matrix switch.

An object of this invention is the provision of a grid coordinate matrix switch capable of accommodating a plurality of replaceable map cards forming subdivisions of a larger map.

Another object is the provision of a matrix switch of this type with means for automatically generating a signal to identify a selected map card when inserted into the operating position.

A further object is the provision of a matrix switch having a multilayer printed circuit board assembly with a pluggable component board to facilitate maintenance.

A further object is the provision of a low-cost matrix switch with grid-forming conductors printed on stacked circuit boards and spaced by resilient separators formed directly on one of the boards by silk screen or printing techniques.

SUMMARY OF THE INVENTION

A binary output matrix switch is capable of receiving one of a plurality of map overlay cards for generating a coded location signal in response to finger pressure at a selected point on the map. Each card carries an identification code which is translated into part of the binary output signal when the card is inserted into operating position. Grid conductors are formed by printed circuit techniques and an easily removed pluggable component board facilitates maintenance and trouble shooting of the unit.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a partially schematic and partially perspective view of a vehicle locator system with a matrix switch embodying this invention;

FIG. 2 is a side elevation, partially in section, of the switch embodying this invention;

FIG. 3 is a perspective view of the switch showing details of the multilayer construction;

FIG. 4 is an exploded view of the multilayer assembly comprising the switch; and

FIG. 5 is a greatly enlarged transverse section of part of the switch assembly taken on line 5—5 of FIG. 3.

DESCRIPTION OF PREFERRED EMBODIMENT

Referring now to the drawings, a position locating system embodying this invention is shown in FIG. 1 and comprises a matrix switch assembly **10** which produces a binary signal output on line **11** in response to finger pressure by the hand H of the operator against the working surface **12** shown, by way of example, as a portion of a city street map. The binary output signal on line **11** is processed by a multiplexer **14** to form a coded binary word representing the coordinates of the finger pressure point on surface **12**. This binary signal is applied to transmitter **15** for transmission over antenna **16** preferably as a tone burst when used in conjunction with a police communication network of the type described in U.S. Pat. No. 3,678,391 of Warren Gough. The transmitted signal is received at the remote station by antenna **17** and is processed in receiver **18** and decoder **19** for presentation on a display unit **20**. A translucent map **21** on the surface of unit **20** is identical to the map on matrix switch surface **12** and is illuminated at point **22** corresponding to the finger pressure point on surface **12** by appropriate lighting means in response to the output of a logic circuit in decoder **19**.

A general system including a binary signal generating matrix switch for vehicle location is described in the aforementioned application of Kent Penwarden and transmitter **15** may comprise a vehicle mounted digital communications unit described in the foregoing patent of Warren Gough. The instant invention resides in the matrix switch assembly **10**.

Switch assembly **10** comprises a generally rectangular housing **24** having a front section **25** and a rear section **26** releasably connected together and a multilayer unit **27** mounted on front section **25**. Front section **25** has side members **25***a* and **25***b* and top and bottom members **25***c* and **25***d*, respectively, defining an unobstructed rectangular opening which is traversed by the working surface or map area **12**. Top member **25***c* and the upper parts of side members **25***a* and **25***b* project forwardly to form a shield and carry indicator lights **29** and **30** on opposite sides for monitoring operation of the switch assembly. In addition to signal output terminal **32**, a power input terminal **33** and a control switch **34** are connected to circuits within the housing and project below bottom member **25***d*.

The utility and practicability of a matrix switch assembly **10** that is to be mounted in an already crowded police patrol vehicle, preferably adjacent the dashboard, is dependent on the compactness of the unit as well as its capability of displaying a sufficient area of a map to be effective. In order to balance these two limits

— minimum overall space occupied and maximum map viewing area — provision is made in housing **24** to accommodate a plurality of replaceable maps or map cards **35** comprising portions of a larger map. To this end, the rearwardly facing edge of top member **25***c* of front section **25** is formed with a transversely extending recess **36** and each of the side members **25***a* and **25***b* has an inwardly opening vertically extending shoulder **38** (see FIG. **5**) aligned in the plane of recess **36.** Recess **36** and shoulders **38** define a slot for reception of map card **35** which comprises a plane rectangular frame **41**, see FIGS. **4** and **5**, enclosing the map **12** and having an upwardly projecting identification tab **42** with a visible code number thereon. In order to store a plurality of map cards **35**, the rear housing section **26** has a compartment **44** with an upper opening **45** through which cards are removed and inserted; the tabs **42** of stored cards are staggered and project above top member **25***c* of the front section so as to be visually as well as physically accessible to the operator. The outline of a map card **35** partially inserted in recess **36** is shown in broken lines in FIG. **1.**

The structure of multilayer unit **27** is shown more clearly in FIGS. **3–5**, inclusive, and comprises a component board **48**, a lower matrix board **49**, an upper matrix sheet **50**, a resilient magnetized cover **51**, an a semi-permanent preferably small scale map **52.** Replaceable map card **35** with a large scale map **12** overlies map **52.** The side edges of matrix board **49** and sheet **50**, cover **51** and permanent map **52** overlie the side edges of component board **48** as shown in FIG. **5** and receive screws **54** which secure these parts to sides **25***a* and **25***b* of front housing section **25.**

Component board **48** is a relatively rigid sheet of 1/16 inch epoxy laminate and mounts circuit components **55** such as gates, flip-flops and core memories which comprise the logic elements of the switch assembly. These components are mounted on one side of the board, the underside as shown in FIGS. **4** and **5**, the upper or top side of the board having printed conductors as shown for making intercomponent and other electrical connections. Board **48** also has terminal sockets **57** and **58** along adjacent side edges, respectively, for providing a releasable connection with the conductors on lower matrix board **49** and sheet **50** as described below. Signal output and power terminals **32** and **33** as well as control switch **34** are physically mounted on component board **48** and are electrically connected to the assembly through this board.

In order to automatically inform the remote station of the identity of a particular map card **35** which has been inserted into operative position in the housing, a plurality of switches **60**, preferably four in number, are mounted on component board **48** and have outwardly projecting fingers **60***a*–**60***d*, inclusive. The lower end of each map frame **41** is formed with notches **62** and teeth **63** defining an identification code for the particular card and switch fingers **60***a*–**60***d* are positioned to cooperate with these notches and teeth. Switches **60** generate a 4-bit coded signal depending on the number and position of fingers **60***a*–**60***d* which are depressed by teeth **63** (or not depressed by notches **62**) and this identification code is transmitted as part of the output signal from the switch assembly; the signal is decoded at the remote station to enable the operator there to use a corresponding map on display unit **20.** The number of switches **60** may be varied to suit the number of codes required to identify the replaceable maps. When no map card **35** is in the operative position, i.e., when small scale map **52** is exposed for use, none of the switch fingers are depressed which constitutes the code for indicating use of this map.

Lower matrix board **49** preferably is made of 1/8 inch epoxy glass laminate or similar material and has a plurality of straight laterally spaced parallel conductors **64** formed preferably by printed circuit techniques on the upper surface **49**a and extending substantially the full length of the board. The ends of conductors **64** are electrically connected to pins **65** which extend along the lower edge, as viewed, and through the board for removable insertion into and electrical connection with aligned terminal sockets **57** on the corresponding edge of component board **48.** Upper matrix sheet **50** is composed of relatively thin (0.004 inch) epoxy glass or similar material and has a plurality of laterally spaced parallel conductors **67** formed on the underside **50***a* and extending substantially the full width of the sheet at right angles to conductors **64** on matrix board **49.** Conductors **67** are connected at one end to terminal elements **68** along the left side edge, as viewed, of sheet **50**; elements **68** extend through sheet **50** and make electrical contact with pins **69** along the corresponding edge of board **49** when these parts are secured together in a stacked position. Pins **69** extend through board **49** and releasably engage sockets **58** in component board **48.**

Conductors **64** and **67** on board **49** and sheet **50**, respectively, are spaced from each other by a plurality of separator strips **71** formed on board **49** and extending parallel to conductors **64.** Preferably one separator strip is located midway between adjacent conductors **64** and is coextensive with those conductors. Strips **71** are composed of a resilient compressible material such as neoprene, synthetic rubber, film rubber, or any other elastomer, which is applied to board **49** by deposition through a silk screen or the like in the manner employed to form masks in printed circuit processes. Thus the height and width of each separator strip is precisely controlled and all the strips are deposited simultaneously and rapidly. For example, the height of each strip which defines the separation gap between board **49** and sheet **50** and thus the length of the switch stroke is approximately 0.002 to 0.004 inch. Sheet **50** is sufficiently stiff to maintain a normally plane shape in the absence of a compressive force to insure separation of matrix conductors **64** and **67** at their crossover points, and yet has the desired flexibility for compressing separators **71** and permitting contact between conductors **64** and **67** in response to such force.

Cover **51** is composed of a resilient magnetized material about 0.030 to 0.040 inch thick and is designed to protect sheet **50** from damage by impact of a sharp object. In addition, the magnetic character of sheet **51** makes it a convenient mechanism for retaining a metallic washer or cursor **73**, see FIG. **3**, on a map surface overlaying the cover to indicate to the operator the last location transmitted by application of finger pressure to the map. A commercially available material useful in forming cover **51** is sold under the trademark Plastiform by 3M Company.

Sheet **52** preferably is a small scale map of an area of interest such as a city or county whereas the replaceable map cards **35** carry large scale maps constituting portions of map **52.** Such a map arrangement permits

the vehicle operator to quickly expose a large area of a city at any time simply by removing the map card **35** in use and also permits him to pinpoint his location more precisely by use of a magnefied view of various parts of that city available through selection of an appropriate map card **35.** The electrical and mechanical operation of the matrix switch assembly **10** is the same with either large or small scale maps, the dispatcher at the remote station being instantly informed by the code switches **60** as to the identity of any map selected for use by the operator in the vehicle.

The use of matrix switch assembly **10** in police communications networks as well as in other systems requires an extremely fast maintenance and repair capability if and when the assembly requires such attention. In order to accommodate this requirement, substantially all of the parts susceptible to failure are carried on component board **48,** i.e., signal output terminal **32,** power terminal **33,** control switch **34,** code switches **60** and all components **55.** Terminal sockets **57** and **58** on board **48** permit rapid electrical connection with and disconnection from pins **65** and **69,** respectively, the remainder of the multilayer unit **27** being securely held to the front housing section by screws **54.** In order to repair a defective switch assembly, rear housing section **26** is removed from front section **25,** the component board is unplugged, a new component board inserted in its place, and the rear housing section is replaced. The entire operation is accomplished in a few minutes.

The dimensional tolerances of map cards frame **41** and shoulders **38** in the side members **25***a* and **25***b* of the front housing section **25** are sufficiently close to permit ready insertion and removal of a map card without substantial play between the map card and the stationary multilayer unit **27.** In order to hold map card **35** stationary when inserted into the operative position, a forwardly extending cam-type projection **75** is formed on each tab **42** of map card **35,** see, FIG. **4,** and is positioned to extend into and engage a transverse groove **76,** see FIG. **2,** in top member **25***c* of front housing section **25** along the inner face of re-cess **36.** Projection **75** snaps into slot **76** when the map card is bottomed in its operative position and the latter is held firmly in that position until intentionally removed by the operator.

What is claimed is:

1. A matrix switch assembly comprising

a housing having an unobstructed opening and a stacked multilayer compression switch supported on said housing and traversing said opening, said unit comprising

a first electrically nonconductive sheet having a first set of laterally spaced parallel conductors on one side,

a second electrically nonconductive sheet having a second set of laterally spaced parallel conductors on a side facing said one side of said first sheet and extending transversely of the direction of said first set of con-ductors,

one of said sheets having a plurality of resilient separators formed thereon for spacing said first and second sets of conductors, each of said separators comprising an elongated strip disposed between adjacent conductors on said one sheet, and

means for generating an output signal in response to an electrical contact between a conductor of the first set and a conductor of the second set.

2. The assembly according to claim **1** in which said strips are parallel to and coextensive with the conductors of said one member.

3. The assembly according to claim **1** in which said conductors have a printed circuit construction.

4. The assembly according to claim **2** in which said strips are permanently bonded to said one member.

5. A matrix switch assembly, comprising

a housing having an opening therein,

a compression switch unit mounted on and within said housing and having a surface traversing said opening, said switch comprising a first set of spaced parallel conductors in a first plane and a second set of spaced parallel conductors in a second plane spaced from the first plane, the conductors in the first set overlying and extending transversely of the conductors in the second set and defining therewith crossover points at which electrical contact is made between conductors of the two sets in response to a compressive force applied transversely of said planes,

said housing having slot means in a plane parallel to and adjacent to said surface, and

card means removably insertable into said slot means to an operative position overlying said surface, said card means being capable of transmitting to said surface of the switch unit said compressive force when applied thereto.

6. The switch assembly according to claim **5** in which a portion of said card means is formed with an identification code, and switch means mounted on said unit and actuated by said portion of the card when the latter is in the operative position for producing an electrical signal corresponding to said identification code.

7. The switch assembly according to claim **6** in which said housing has a compartment adapted to receive and store a plurality of said card means.

8. The switch assembly according to claim **7** in which each of said card means is formed with a different identification code for generating a corresponding electrical signal whereby automatically to distinguish the card means from each other when inserted into said operative position.

9. The switch assembly according to claim **8** in which said housing has a transverse groove in a portion thereof defining said slot, each of said card means comprising a frame and a flexible sheet mounted in said frame, said frame having a projection engageable in said groove when the frame is in the operative position in said slot.

* * * * *