An electrical connector for interconnecting a display to a printed circuit board is disclosed. One application of the invention provides a connection between a liquid crystal display (22) ("LCD") and a circuit board (26). The connector (23) is capable of serving a dual function as a lightguide that transmits light for the display (22), and as an electrical connector for interconnection of the display with the circuit board. A leg member (25) is mounted on the connector, and the leg member includes a row of contact feet (27) for electrical communication. The connector may include a plurality of spaced apart U-shaped strip members (43) mounted in parallel upon a leg member, with contact feet (41, 42) that extend upwardly to reliably mate with contact pads (28) of a printed circuit board (26).
CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG). For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

Published:
— with international search report
Title of the Invention

ELECTRICAL CONNECTORS FOR DISPLAY DEVICES

Cross Reference to Related Applications

This application claims priority to application U.S. Serial No. 09/821,828 entitled: "ELECTRICAL CONNECTORS FOR DISPLAY DEVICES" filed 29 March, 2001.

Background of the Invention

The present invention relates to electrical connectors in general, and more particularly to electrical connectors used to interconnect a display device such as a liquid crystal display ("LCD" or "LCD's") to a circuit board, in a stacked configuration.

Prior art methods and devices are known for interconnecting electronic assemblies. Such methods and devices are used to connect relatively small components to adjacent electronic components, such as circuit boards.

With present-day electronic components, a significant problem with conventional methods and devices for interconnecting LCD's to their respective associated electronic components is the limited space afforded for such connections and assembled components. To reduce the overall size of the end product, it is desirable to vertically "stack" such components when possible. LCD’s may be arranged in a vertically stacked arrangement. LCD’s often are provided in connection with a lightguide device that is incorporated into the stack and adapted for distributing light around the periphery of an LCD. A typical LCD assembly mounted upon a cellular telephone, for example, includes an upper display portion and a lower circuit board portion. Sandwiched between the LCD and the circuit board is the optical lightguide. Occasionally, a connector is provided between the LCD and circuit board (i.e. adjacent the lightguide device).

Historically, LCD’s have employed connections which appear under the display, with a semiconductor chip located away from the
display, such as on the circuit board itself. However, modern LCD devices sometimes mount a semiconductor chip on the glass of the upper display. A chip mounted on the glass of the upper display is helpful in some instances because it reduces the overall number of contact pads that must be provided on the surface of the LCD, due to the lesser number of communications that must be made in that instance.

Connectors designed to interconnect an LCD with a circuit board typically have been comprised of elastomeric or foam material that springs back when compressed. For example, U.S. Patent No. 5,709,576 to Lippmann discloses an elastomeric connector that couples terminal pads of an LCD with corresponding terminal pads of a printed wiring board. Sense pads are located on the terminal strips and arranged so that a continuity test on substantially opposed contact pads will verify pad alignment. In some applications, the tendency of such elastomeric materials to resume their original shape after deformation sometimes is relied upon as a means to hold contacts in close association within the sandwich structure, which is tightly pressed together during use.

United States Patent No. 6,220,892 is directed to an electrical connector interconnecting a microphone with an insulating body that is designed to connect a microphone to a circuit board. The insulating body defines an internal receptacle having a shape for receipt of a microphone. An outer surface of the body is configured for disposition adjacent an conductive member, for example a circuit board, to which the microphone is to be electrically connected. A pair of connector elements are configured with the body.

Elastomeric connectors may feature solderless contacts that connect the electrical contact pads on the LCD display with those on the printed circuit board. However, such elastomers sometimes lose their elasticity. It is sometimes observed that electrical connection becomes faulty in such LCD’s after a period of time. Elastomeric materials of this
type usually comprise rubbery or foamed materials that lose some of their elasticity due to age, heat, or a combination of age and heat. When a loss of elasticity occurs, the electrical connection, which depends upon such elasticity to hold contacts in resilient communication with each other, may become faulty. Slight movement of the elastomeric connector at high temperatures or in the presence of vibration may cause undesirable conductivity problems.

It has been observed that it is quite often difficult to solder or connect the terminals or connectors between adjacent components without bridging adjacent terminals with solder. Also, it is difficult to maintain and ensure the correct relative position (sometimes called "registration") between the components both during the manufacturing process and in subsequent use of the end product.

What is needed in the industry is a connector that is capable of integration with a liquid crystal display in a reliable and compact arrangement. A display apparatus employing a connection system that facilitates long term and reliable use of LCD’s at elevated heat and vibrational conditions, by making secure electrical communication, would be very desirable. A system and apparatus that facilitates reliable registration of electrical contacts during manufacture and use also is needed.

**Summary of the Invention**

In the invention, an electrical connector for interconnecting a liquid crystal display to a circuit board is provided. The connector comprises an insulating body, the body being comprised of a material having a configuration that is capable of transmitting light to illuminate the liquid crystal display. In some applications, the connector, which has components capable of transmitting or dispersing light, is called a "lightguide". An insulating body is adapted for transmitting light to illuminate a display. A leg member is disposed on the insulating body, and includes an outer surface that is configured for disposition adjacent
to a circuit board to which the liquid crystal display has been electronically connected. Furthermore, at least one connector element is configured with the insulating body.

In one embodiment of the invention, the connector element may comprise a first contact foot that extends beyond the outer surface of the leg member, to enable electrical communication with the liquid crystal display. Furthermore, a second contact foot extends beyond the outer surface of the leg member for electrical communication with a circuit board. In this embodiment, the connector is positioned for registration of the connector elements with electrical contacts that are located on the LCD and the circuit board.

In one embodiment of the invention, the connector element includes a “U-shaped” member with a first end and a second end, wherein the U-shaped member has an arm portion with contact feet defined on the first end and contact feet defined on the second end. The connector element also comprises a closed-end that wraps around and fits upon the leg member configured in the body.

In another embodiment of the invention, the connector includes an opening that is provided in the body itself. Furthermore, the leg member includes a plurality of connector elements that are aligned and separated from the body. The opening in the body is located at least partially between the leg member and the body.

At least one embodiment of the invention includes connector elements that comprise strip members which are bent into a closed-end and oppositely facing arms configuration. The contact feet are defined on the arms, and at least one of the arms is adapted for applying a resilient force to electrical contacts of the LCD.

Additional objects and advantages of the invention will be set forth in part in the following description, or may be apparent from the description, or may be learned through practice of the invention.

**Brief Description of the Drawings**
A full and enabling disclosure of this invention, including the best mode shown to one of ordinary skill in the art, is set forth in this specification. The following Figures illustrate the invention:

Figure 1 is a perspective view of the liquid crystal display assembly showing the connector adapted for electrically contacting the display and the circuit board;

Figure 2A shows an exploded view of the components of the liquid crystal display, including the connector assembly;

Figure 2B is a side view of the assembly showing the lightguide;

Figure 3 is a perspective view of the underside of the assembly, wherein the portions of the assembly are separated for easy identification;

Figure 4 is a tip view of the insulating body (sometimes called a "lightguide") of the invention;

Figure 5 is an end view of the insulating body shown in Figure 4;

Figure 6 is a side view of the insulating body shown in Figures 4-5;

Figure 7 is a cross-sectional side view of the insulating body shown in Figure 6;

Figure 8 is a second cross-sectional side view similar to that shown in Figure 7 except that the contacts in Figure 8 are depressed as when the assembly is fully connected in the assembled configuration.

Figure 9 is a perspective view of an alternate embodiment of the invention having a contact connection on the top surface of the LCD display;

Figure 10 is a cross-sectional side view of a portion of the structure shown in Figure 9, taken along lines 10-10 shown in Figure 9.

**Detailed Description**

Reference will now be made in detail to the presently preferred embodiments of the invention, one or more examples of which are illustrated in the drawings. Each example is provided by way of
explanation of the invention, and not meant as a limitation of the invention. For example, features illustrated or described as part of one embodiment can be used in another embodiment to yield still a further embodiment. It is intended that the present invention include such modifications and variations.

Radiotelephones, such as cellular telephones, have become increasing popular for both personal and commercial use. Radio telephones have become smaller to provide more convenient storage and portability. Consequently, the space or "real estate" on circuit boards which host electronic components within radiotelephones has become limited and valuable.

A lightguide is a structure provided within an illuminated electronic device such as a radiotelephone for example that may be utilized to illuminate a key pad of translucent keys by way of a light source that is internal to the device. The lightguide may also be utilized to support a key pad and a liquid crystal display for a radiotelephone. The lightguide may be placed directly on a circuit board for hosting electronic components to generate and receive telecommunications signals. As a result, a lightguide may occupy a significant amount of circuit board real estate. As a result, circuit board space beneath a lightguide may be generally unusable for hosting electronic components.

One or more wall portions may depend from a face of the lightguide to maintain a spaced apart relationship between the lightguide and the circuit board. These wall portions may be configured to contact the circuit board face to thereby define one or more compartments between the circuit board face and the lightguide face when the lightguide is secured within the housing.

In general, the invention as disclosed herein may be used with cellular or radiophones or essentially any other electronic device which includes a liquid crystal display. Contact areas, called ITO pads (Indium Tin Oxide), comprise small contact areas on the surface of a display that
provide an electrical communication path between the connector and the display.

In the invention, a lightguide and connector combination is provided to perform a dual function. First, the combination component operates as a light dispersal device, and second, it operates as a connector and insulator. Typically, one or more light emitting diodes provides a source of light that is dispersed or transmitted by a lightguide. The lightguide is adapted to reflect light towards the liquid crystal display. A light source provides light that is received by a lightguide, and the light is then focused, thereby reducing the loss of light through the lightguide, as further provided below.

Turning to Figure 1, a connector assembly 11 is shown in perspective view in which a liquid crystal display 22 (LCD) is in the upper part of the Figure. A connector 23 is shown below the liquid crystal display 22, the connector 23 having an insulating body 24 that is adapted to connect with a circuit board 26. Connector elements 27 are provided in a row along a leg member 25 on the connector 23. The connector 23 has an insulating body 24 that is adapted to transmit light to illuminate the liquid crystal display 22 when the assembly is integrated, as further described below. Registration hole 29a is adapted for receipt of the alignment pin 37a, which places the connector elements 27 exactly in correct registration with contact pads 28 of the circuit board 26.

Figure 2A shows an exploded view of the connector assembly 11. In the invention, one or more light emitting diodes ("LED") 16a-b may be provided as a light source(s). The light emitting diodes 16a-b usually are plugged into and powered by electrical communication with the printed circuit board 26, where they are mounted. The number of light emitting diodes 16a-b could be as few as one, or as many as a dozen or more. In one embodiment, two of such light emitting diodes 16a-b have been found to be satisfactory. Focusing elements 18a and 18b serve to focus light generated by the light emitting diodes 16a-b upon the
insulating body 24. An upper surface 20a of the insulating body 24 is shown. A backing card 14 is an optional feature that may rest just below the insulating 24.

Insulating body 24 may be constructed of clear polycarbonate, or other suitable polymeric or acrylic material. One suitable material is available from Bayer Chemical Company under the trade name "MAKRALON" ("Mackralon" is believed to be a trademark of the Bayer Chemical Company). The thickness of the insulating body 24 typically is less than about 2 mm, and more preferably less than about 1 mm, and may be less than or equal to 0.7 mm in some particular embodiments of the invention.

The light emitting diodes 16a-b usually are arranged so that the light path of light leaving the diodes 16a-b is angled towards one another. Focusing elements 18a-b are configured to bend the light received from the light emitting diodes 16a-b towards or into the plane of the insulating body 24. In general, there is a low angle between the light paths within the insulating body 24. Much of the light within the insulating body 24 may be reflected by internal reflection, thereby reducing loss of light during passage through the insulating body 24. Some of the reflected light is directed upwardly towards the liquid crystal display 22.

Figure 2B shows a side view of part of the connector assembly 11. Operation of the insulating body 24 may be observed by reference to this Figure 2B, in which the liquid crystal display 22 is provided over insulating body 24 having focusing elements 18a-b. The insulating body 24 includes an upper surface 20a and a lower surface 20b, with a printed circuit board 26 located beneath the insulating body 24. A backing card 14, in some embodiments, may be provided between the printed circuit board 26 and the insulating body 24. A light emitting diode 16 located within a housing 17 provides a source of light. An internal reflective surface 15 of the housing 17 provides for maximum light reflectance into
the insulating body 24. Typically, the insulating body 24 is provided with surface formations (not shown) that reflect and scatter light emitted from the light emitting diodes 16a-b upwardly towards the liquid crystal display 22. A backing card 14 assists in providing an even light intensity over the entire surface of the liquid crystal display 22, so that it is not necessary to provide light from all four corners of the device. The optional backing card 14 is provided to shield the printed circuit board 26 from view, and may be white in color to enhance brightness. Another means of concealing the printed circuit board 26 is to apply an opaque coating to the underside or lower surface 20b of the insulating body 24.

Figure 3 shows an exploded view of the connector assembly 11 from the bottom, revealing the circuit board 26 having registration holes 29a-b on its lower surface. Furthermore, the leg member 25 of the connector 23 is shown, having alignment pin 37b which is adapted for insertion into registration hole 29b. Furthermore, liquid crystal display 22 receives light from the connector 23. Connector elements 27 located along the leg member 25 are adapted to interact with contact pads 38 of the liquid crystal display 22 on the upper surface of the connector 23, and the connector elements 27 interact with the circuit board 26 below the surface of the connector 23.

In Figure 4, a top view of the connector 23 is shown. The insulating body 24 includes along one side a leg member 25 having connector elements 27 spaced along the leg member 25. On opposite sides of the insulating body 24, registration features 39a and 39b are shown, which are oriented opposite registration features 39c and 39d. The registration features 39a-d are provided to interlock the connector 23 with corresponding features located on the edge of circuit board 26 (not shown in Figure 4). These registration features 39a-d ensure that the connector 23 is provided at exactly the right location to mate the connector elements 27 with their corresponding contact pads on both the liquid crystal display 22 and the circuit board 26. Furthermore, the
registration features 39a-d also assist in securing the connector 23 to avoid unnecessary vibration or movement during use.

Figure 5 shows an end view of the connector 23 shown in Figure 4, with connector elements 27 along the leg member 25, which is attached to the insulating body 24. On either side of the connector 23 are alignment pins 37a-b. Furthermore, registration features 39a and 39c are seen on the edge of the connector 23.

Figure 6 shows a side view of the connector 23 in which an insulating body 24 is shown with alignment pins 37a and 37c shown on the underside of insulating body 24. A first contact foot 41 and a second contact foot 42 extend above and below, respectively, the leg member 25 for electrical communication.

In Figure 7, a cross-section is taken along lines 7-7 (see Figure 4) which reveals an insulating body 24 separated by an opening 46 from the leg member 25. The opening 46 is the point at which a carrier strip (not shown) is used during manufacture of the connector 23, in which the carrier strip is “punched out” through the opening 46 during manufacture at the point at which the “u-shaped” member 43 is secured to the leg member 25. The u-shaped member 43 has an arm portion 44 and an arm portion 45 on either end. Furthermore, a first contact foot 41 and a second contact foot 42 flexibly engage or connect on the top and bottom sides of the insulating body 24.

In Figure 8, a cross-section is provided similar to that of Figure 7, except that an alternate embodiment of the connector 123 is shown having a flat bonded contact 141 adapted for bonding to the LCD display. A flat arm portion 144 is provided that extends from u-shaped member 143. Arm portion 145 extends downward from the connector 123 for mating contact with a printed circuit board 139. A contact foot 142 extends down from arm portion 145. Opening 146 provides a space between the insulating body 124 and the leg member 125. Alignment pin 137a is shown below the connector 123, providing a means for securing
the connector 123 in registration with other electronic components for operation.

Figure 9 shows yet another embodiment of the invention in which integrated assembly 132 includes leg member 225 provided in a configuration that facilitates electrical contact on the upper surface of liquid crystal display 222 (LCD), as shown in Figure 9. In Figure 9, liquid crystal display 222 is mated to the connector, which in turn is mated to a circuit board 226 shown in the lower portion of Figure 9.

In Figure 10, a partial cross section taken along lines 10-10 of Figure 9 is shown. A connector 223 includes a u-shaped member 243 which wraps around leg member 225 of the assembly 132. The u-shaped member 243 includes arm portion 244 and arm portion 245. A contact foot 242 is adapted for resilient contact with a printed circuit board 226 (not shown in Figure 10) having a contact pad 250. An upper contact foot 241 is resiliently engaged to the upper surface of the liquid crystal display 222. The display may have contact pads aligned in registration with a plurality of contact elements as shown in Figure 9 on top of the liquid crystal display 222. An alignment pin 237a on the underside of the insulating body 224 is provided as well for aligning the components in registration. Opening 246 is shown adjacent the insulating body 224 of connector 223.

When the integrated display assembly 132 of Figure 9 is assembled, the connector 223 is put together by mechanically placing the liquid crystal display 222 on top of the insulating body 224 of the connector 223, and against the inner surface of the leg member 225, thereby facilitating contact between contact foot 241 and the top surface 252 of the liquid crystal display 222. The contact foot 241 usually but not always resiliently contacts ITO pads (not shown in Figure 10) on the upper surface of the liquid crystal display shown. However, in other applications, there may be conductive traces or conductive lines that receive the contact feet, such as contact foot 241.
It should be appreciated by those skilled in the art that various modifications and variations can be made in the present invention without departing from the scope and spirit of the invention. It is intended that the present invention include such modifications and variations as come within the scope and spirit of the appended claims and their equivalents.
What is Claimed:

1. An electrical connector for interconnecting a display to a circuit board, in a stacked configuration, the connector comprising:
   an insulating body, the body being comprised of a material that is capable of transmitting light to illuminate a display;
   a leg member, the leg member disposed on the body, the leg member having an outer surface configured for disposition adjacent a circuit board to which the display is to be electronically connected; and
   at least one connector element configured upon the insulating body.

2. The connector of claim 1 wherein:
   the connector element comprises a first contact foot extending beyond the outer surface for electrical communication with the display and a second contact foot extending beyond the outer surface for electrical communication with the circuit board; and
   the connector is positioned for registration of the connector elements with electrical contact pads located on the liquid crystal display and the circuit board.

3. The connector as in claim 2, wherein the connector element comprises a U-shaped member with a first end and a second end, the U-shaped member having an arm portion with contact feet defined on the first end, and an arm portion with contact feet defined on the second end, the connector element further comprising a closed-end wrapping around and fitted onto the leg member configured in the body.

4. The connector of claim 3 in which a plurality of connector elements are aligned on the leg member of the insulating body.

5. The connector of claim 4 in which an opening is provided in the body, wherein the leg member having a plurality of connector elements
aligned thereon is separated from the body, the opening in the body being located at least partially between the leg member and the body.

6. The connector of claim 4 in which the contact feet of the connector element are adapted to mate with contact pads upon the display.

7. The connector of claim 4 in which the contact feet of the connector element are adapted to mate with contact pads upon the circuit board.

8. The connector as in claim 3, wherein the connector elements comprise strip members bent into a closed-end and oppositely facing arms configuration, said contact feet defined on said arms, at least one of the arms being adapted for applying a resilient force to electrical contacts of the display.

9. The connector as in claim 8, wherein at least one of the arms is adapted for applying a resilient force to electrical contacts of the display.

10. A display apparatus having a dual function connector, the connector being adapted for operating both as a lightguide to facilitate illumination of a liquid crystal display and as an electrical connector for interconnecting the liquid crystal display to a circuit board, in a stacked configuration, comprising:
   (a) a liquid crystal display having contact pads on its lower surface;
   (b) a circuit board having contact pads on its upper surface;
   (c) a connector, the connector having an upper and lower surface, the connector being adapted to electrically connect to the liquid crystal
display on its upper surface, and to a circuit board on its lower surface, the connector comprising:

i) an insulating body, the body being comprised of a material that is capable of transmitting light to illuminate the liquid crystal display;

ii) a leg member, the leg member being disposed on the body, the leg member having an outer surface configured for disposition adjacent a circuit board to which the liquid crystal display is to be electronically connected on its lower surface; and

iii) a plurality of parallel connector elements configured with the insulating body, at least one connector element comprising a first contact foot extending beyond the outer surface of the leg member for electrical communication with a contact pad of the liquid crystal display on the upper surface of the connector, and a second contact foot extending beyond the outer surface of the leg member for electrical communication with a contact pad of the circuit board on the lower surface of the connector.

11. The display apparatus as in claim 10, wherein at least one of the parallel connector elements comprises a U-shaped member with a first end and a second end, the U-shaped member having an arm portion with contact feet defined on the first end, and an arm portion with contact feet defined on the second end, the connector element further comprising a closed-end wrapping around and fitted onto the leg member configured in the body.

12. The connector of claim 11 in which at least two of the connector elements comprise U-shaped members have a first end and a second end, the U-shaped members having an arm portion with contact feet defined on the first end, and an arm portion with contact feet defined on the second end, the connector element further comprising a closed-
end wrapping around and fitted onto the leg member configured in the body.

13. The connector of claim 12 in which an opening is provided in the body, wherein the leg member includes a plurality of connector elements aligned thereon which are separated from the body such that the opening in the body is located generally between the leg member and the body.

14. The connector as in claim 12, wherein the connector elements comprise strip members bent into a closed-end and oppositely facing arms configuration, said contact feet defined on said arms, at least one of the arms being adapted for applying a resilient force to electrical contacts of the liquid crystal display.

15. The connector as in claim 14, wherein at least one of the arms is adapted for applying a resilient force to electrical contacts of the liquid crystal display.

16. A system for interconnecting a liquid crystal display to a circuit board, comprising:
   (a) a liquid crystal display having contact pads;
   (b) a circuit board having contact pads on its upper surface;
   (c) a connector, the connector having an upper and lower surface, the connector being adapted to electrically communicate with the liquid crystal display on its upper surface, and to a circuit board on its lower surface, the connector comprising:
      i) an insulating body;
      ii) a leg member, the leg member being disposed on the body, the leg member having an outer surface configured for disposition
adjacent a circuit board to which the liquid crystal display is to be electronically connected; and

iii) a plurality of parallel connector elements configured with the insulating body, at least one connector element comprising a first contact foot and a second contact foot, the first contact foot extending beyond the outer surface of the leg member for electrical communication with a contact pad of the liquid crystal display on the upper surface of the connector, and the second contact foot extending beyond the outer surface of the leg member for electrical communication with a contact pad of the circuit board on the lower surface of the connector.

17. The system of claim 16 in which at least one of the connector elements is comprised of a U-shaped member.

18. The system of claim 17 in which U-shaped member comprises an arm portion with contact feet defined on the first end, and an arm portion with contact feet defined on the second end, at least one connector element further comprising a closed-end wrapping around and fitted onto the leg member configured in the body.

19. The system of claim 18 in which the connector further comprises a locating pin.

20. The system of claim 18 in which the contact feet are curved inwardly, thereby providing for resilient contact with contact pads.

21. The system of claim 16 in which the connector is adapted for transmitting light upon the liquid crystal display to illuminate the display.
22. The system of claim 16 in which the contact feet on the upper surface of the connector interact with contact pads on the liquid crystal display on the upper surface of said liquid crystal display.

23. The system of claim 22 in which the liquid crystal display comprises an outer edge, wherein said contact feet wrap around the outer edge of the liquid crystal display and extend downwardly upon the top surface of the liquid crystal display for electrical communication with said liquid crystal display.
INTERNATIONAL SEARCH REPORT

A. CLASSIFICATION OF SUBJECT MATTER
- IPC(7) : H01R 12/00
- US CL : 439/66, 910
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED
- Minimum documentation searched (classification system followed by classification symbols)
  - U.S. : 439/66, 910; 349/149

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched
- NONE

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
- NONE

C. DOCUMENTS CONSIDERED TO BE RELEVANT

<table>
<thead>
<tr>
<th>Category</th>
<th>Citation of document, with indication, where appropriate, of the relevant passages</th>
<th>Relevant to claim No.</th>
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<td>Y, E</td>
<td>US 6,312,263 B1 (HIGUCHI et al) 06 November 2001 (06.11. 2001), figure 8A.</td>
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Further documents are listed in the continuation of Box C. See patent family annex.

Date of the actual completion of the international search: 29 July 2002 (29.07.2002)

Date of mailing of the international search report: 28 AUG 2002

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