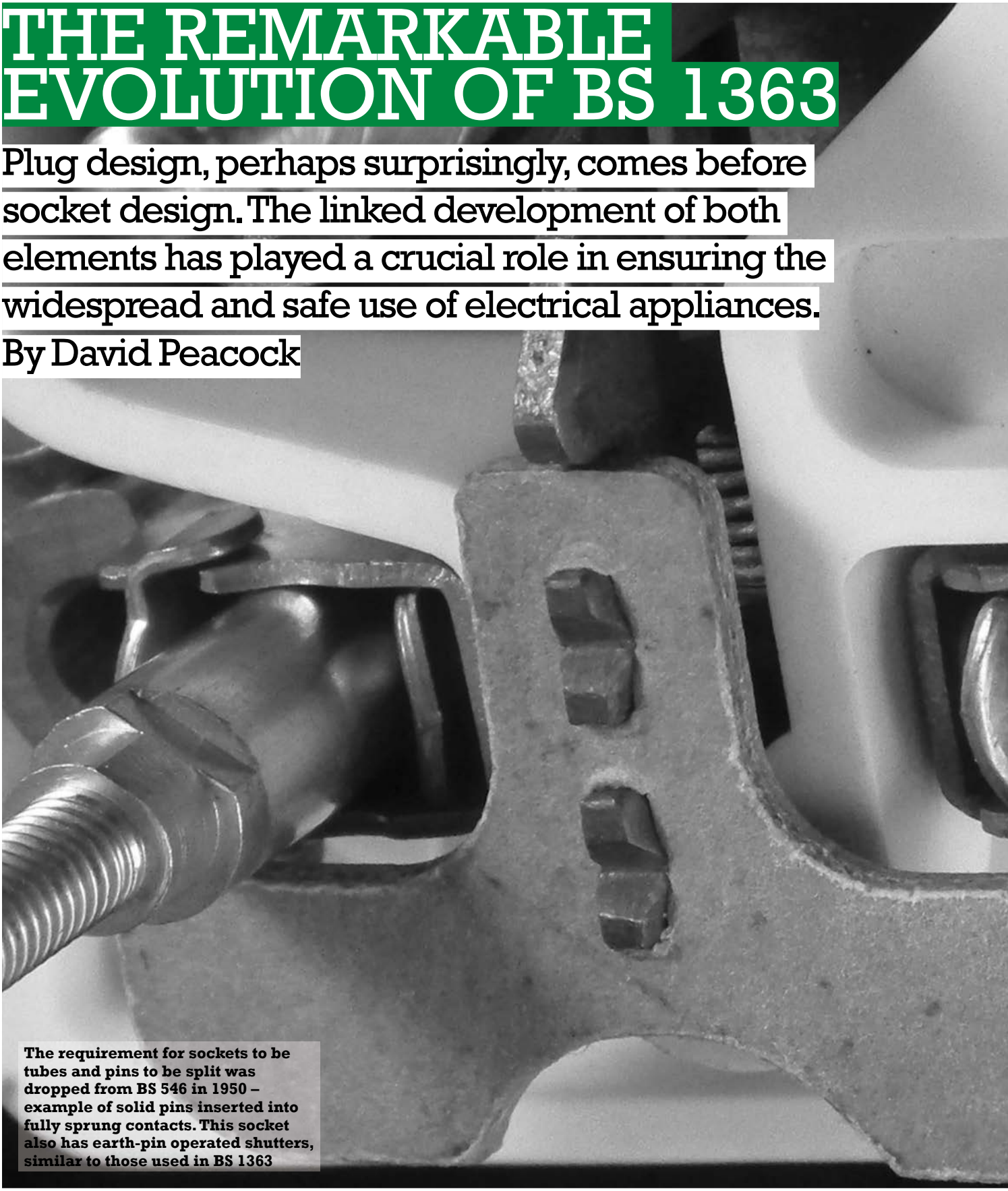
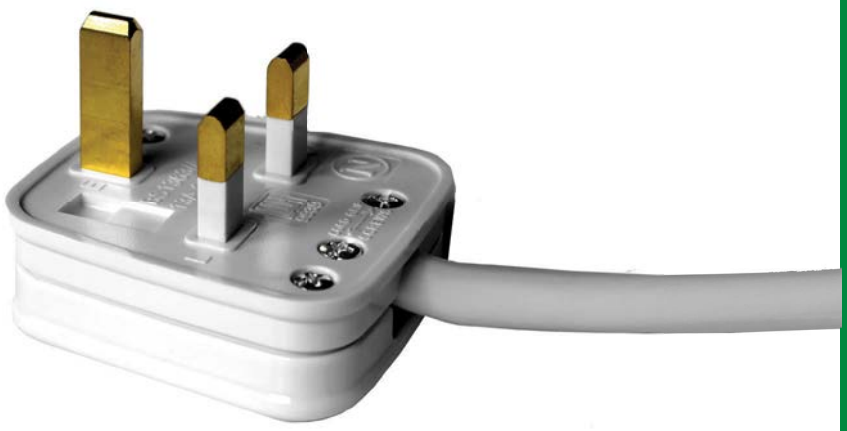
THE REMARKABLE EVOLUTION OF BS 1363

Plug design, perhaps surprisingly, comes before socket design. The linked development of both elements has played a crucial role in ensuring the widespread and safe use of electrical appliances.

By David Peacock



The requirement for sockets to be tubes and pins to be split was dropped from BS 546 in 1950 – example of solid pins inserted into fully sprung contacts. This socket also has earth-pin operated shutters, similar to those used in BS 1363



THERE IS A COMMON assumption that a 13A mains plug is made to fit a 13A socket, but actually it is the other way round. The misunderstanding probably arises from the fact that a socket is normally fixed to the building and therefore appears to be the more fundamental and permanent object; however, it is the plug that is precisely defined, and socket designers have a degree of freedom – subject to the socket accepting all compliant plugs. The insertion of non-compliant plugs can damage sockets.

The BS 1363 socket in use today was the result of an extensive and comprehensive study into the needs of post-war housing. It was first introduced in 1947, and many decades-old sockets are still in use. Plugs, being attached to portable appliances, typically have a much shorter life. A plug is a much simpler device than a socket; its pins are a fixed size and are (mostly) held in fixed positions, and it normally has no moving parts. A socket must have self-adjusting contacts and moving shutters to prevent access to live parts when no plug is in place; as such, it is a more complex device. One of the objects of a standard for plugs and sockets is to ensure that all will work together. Today, it is a normal for a plug and socket to originate from different manufacturers, but this was not always the case.

Timeline: plugs and sockets

The following is a list of the significant milestones in the development of British domestic plugs and sockets for mains use (Note: Some types that have not been the subject of a British Standard are not included):

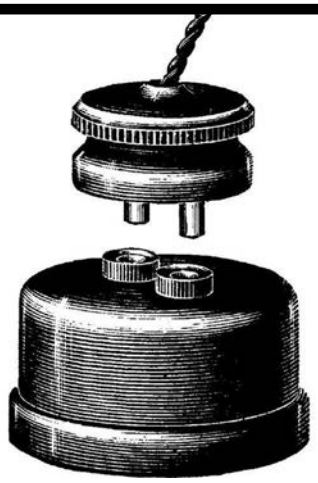
- **1880s – The earliest two-pin plugs and sockets in UK were introduced in the 1880s.**
- **1893 – GEC catalogue includes two-pin plugs and sockets sold only as pairs. Crompton & Co introduced the first shuttered socket.**
- **1911 – GEC catalogue emphasises two-pin plugs and sockets which are interchangeable; plugs also now available separately. Similar plugs are available from other manufacturers including AP Lundberg which also offer three-pin earthing plugs and sockets.**
- **1915 – First official standardisation of domestic plugs and sockets, BS 73, for 5A two-pin. Dimensions of both plug pins and socket contact tubes are specified, slots in pins provide a sprung contact.**
- **1919 – BS 73:1919 adds 15A and 30A two-pin plugs and sockets.**
- **1927 – BS 73:1927 adds 2A two-pin plugs and sockets.**
- **1928 – First official standard for two-pin and >**

earth domestic plugs and sockets, BS 317, 2A, 5A, 15A and 30A ratings. As with BS 73, the dimensions of both plug pins and socket contact tubes are specified, with slots in pins. The pin spacing differs from the two-pin types.

- **1930 – BS 372 first published. Part 1 superseded BS 73:1927 with minor alterations. Part 2 superseded BS 317 with minor alterations.**
- **1934 – BS 546 first published; superseding BS 372 Part 2 (Part 1 remained the standard for two-pin). The standard specifies interchangeability with BS 372 Part 2, and continues to specify dimensions of plug pins, with slots. For the first time the dimensions of the socket contact tubes are not specified; instead they are required to make good contact with the specified plug pins.**
- **1936 – MK granted patent for earth-pin operated shutter in the form still familiar today.**
- **1947 – BS 1363 published, the first BS to require shutters. The size and shape of the plug's flat pins are fully specified, but the socket contacts are required to operate with plug pins having minimum allowable dimensions.**
- **1950 – BS 546:1950 no longer specified that socket contacts should be tubes.**
- **1984 – BS 1363 modified to require that the line and neutral pins of plugs be partially sleeved to provide an additional level of safety.**

BS 1363

BS 1363 plugs and sockets are defined by having precisely dimensioned plug pins but allowing a degree of flexibility in the design of the socket. Apart from the overall size and the position of fixing holes, the only dimensions specified in BS 1363 for sockets are the minimum distance which the plug must be inserted before live pin contact is made, the maximum dimensions of the pin apertures and their minimum distance from the periphery of the socket. The designer of a socket must take into account the specified dimensions, tolerances and shape of plug pins, and their disposition. The requirement for the earth pin to make and break connection before the live pins is a factor when designing the socket contacts.



A two-pin plug and socket from the 1893 GEC catalogue

Bakelite 15A earthed plug by GEC to BS 546 – date unknown, but note the use of sleeved pins

1928 wooden-bodied 5A earthed plug by GEC, apparently to BS 317

Ceramic-bodied 15A plug by AP Lundberg and Sons, London, circa 1915

Plugs are made by a large number of manufacturers and in many types, including those integrated into adaptors and plug-top devices. It is important that all products intended to be used with BS 1363 sockets conform to the dimensions and required pin shape of a BS 1363 plug. The conformance of a standard plug is controlled by the Plugs and Sockets regulations, other devices intended to be inserted into a BS 1363 socket are excluded from those regulations, but their conformance is equally important.

It should be obvious that the length and cross-section of a pin is critical to its ability to fit the corresponding socket contacts; however it is not uncommon for devices such as chargers, travel adaptors and socket covers to be made with pins of the wrong size. A pin that is too long may prevent the plug being fully inserted, and might damage the base of a socket. A pin that is too thin may not make satisfactory contact with the socket, with the potential risk of arcing and overheating. A pin that is too thick may stretch a socket contact beyond its ability to maintain a firm contact on a conforming pin – and could lead to arcing and overheating when the socket is again used with a conforming plug.

For safety reasons, the line and neutral pins of a BS 1363 plug are required to make contact near their tips only. A pin that is too short, or has a chamfer that extends too far, will not make proper contact. If the line and neutral socket contacts do not apply pressure to the flat parallel surfaces of the pins, but to the angled surface of the chamfer, there will be a squeezing effect, which tends to eject the pins. This effect is often found on socket cover pins which commonly fail to meet the standard dimensions (see http://tinyurl.com/PinPopOut).

By contrast, contact with the earth pin may be made at any point on the pin, and a common feature has been to have the earthing contact extended to the surface of the faceplate. Such a feature does not allow for a widening of the contact mouth, so the chamfer on the tip of the earth pin becomes critical to opening the contact. If there is no chamfer it will be impossible to insert the pin, and any attempt at insertion using excessive force can cause the earth contact to buckle.

BS 1363 sockets are required to have automatic shutters that cover the apertures for the line and neutral pins when no plug is present. The traditional method of operating these shutters is for the insertion of the earth pin to cause a sliding shutter to be moved, thus allowing insertion of the other two pins. This operation depends upon the correct dimensions of the earth pin, and the shape of its tip. If the earth pin is not compliant the shutters may not fully open and, if force is used to insert the plug, damage to the shutters may result. The earth pin method is still used by lower-cost sockets, and virtually all adaptors and extension sockets.

More secure alternatives

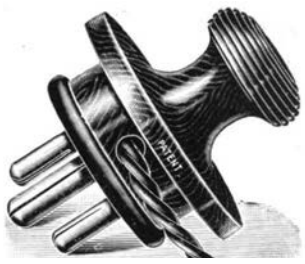
From 1957 onwards an alternative, more secure,

method of operating the shutters was permitted – based on the simultaneous insertion of any two or more pins. Pressing the pins against the sloping surface of the shutter causes a sliding or rotational movement of the shutter plate to expose the contacts. To avoid operation by a single pin, the shutter plate is normally mounted on a rocker; thus, if pressure is applied on only one side, the other is pushed back on a locking catch preventing opening. Operation by the insertion of a Europlug is prevented by having depressions in the plate to trap the Europlug's 4mm round pins (BS 1363 requires that shutters cannot be operated by a Europlug).

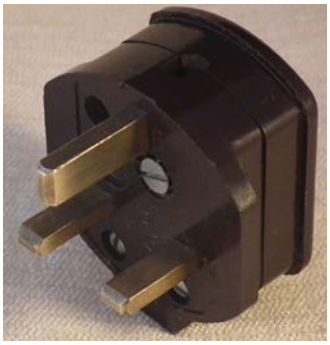
In more recent times the two-pin opening method has been superseded by various patented three-pin systems. In these, the insertion of the earth pin releases a locking mechanism on the shutters, which may then be opened by simultaneous pressure from the other two pins.

The MK and Legrand mechanisms rely on latches operated by the flat sides of the earth pin, the Hagar mechanism uses a latch which is operated by the upper surface of the earth pin. In all cases it is important that the earth pin is of the specified shape and size. If the earth pin (or insulated shutter opening device – ISOD) fails to release the locking mechanism, then the application of excess pressure to the locked shutters while attempting to insert the plug or socket cover may damage the shutters.

One example of this problem is the Clippasafe socket cover which has an 'earth pin' that is non-conforming in a number of aspects. The angled upper surface is incapable of lifting the Hager latch mechanism, and the lack of chamfers prevents insertion into some earth contacts.



A 1891 earthed plug by AP Lundberg and Sons, London – note similarities to the later BS 546 type



Classic early BS 1363 MK 13A plug, prior to the requirement for sleeved

5A two-pin plug with wooden body, probably pre-WW1 [South Western Electricity Historical Society]

Clippasafe socket cover, an example of a product with pins unsuited for use with BS 1363 sockets – the 'earth pin' is the wrong shape

By meeting the requirements of BS 1363-2, the socket designer will ensure that the resulting product will correctly mate with all BS 1363 plugs (those which conform to the 1947 original, or any subsequent version). However, if the dimensions and/or shape of a plug or other device intended to be inserted into a BS 1363 socket deviate from the standard, then it is not possible to predict what will happen when inserted into a socket. Correct interoperability of all plugs and devices incorporating plugs in all conforming sockets can only be assured if BS 1363-1 dimensional requirements are fully met.

The test of time

The members of the committee who originally specified the BS1363 plug and socket were very aware of the need to make provision for entirely unskilled users. They also wanted to make the use of electrical appliances as convenient as possible. It is a mark of the success of the design that it has lasted for over 65 years and has been adapted far beyond the originally foreseen uses.

There are many sockets that have been in use for decades, even possibly some dating from 1947. Many users take these sockets largely for granted and will have a very limited understanding of their technical requirements or the risks which might result from unseen damage. They may equally fail to recognise the signs of damage caused by devices that do not conform to the standard or understand the dangers of damaged contacts. Overheating of line and neutral pins may be an obvious danger but is much greater for unattended appliances or sockets concealed behind large appliances.

Damaged earth contacts may go unnoticed until a possibly fatal accident happens. It unlikely that the vast majority of domestic installations are periodically inspected and tested, except possibly when houses are bought and sold. Even then there is no certainty that every single earth contact, included both contacts of twin socket outlets, will be tested. A damaged earth contact presents an immediate danger as soon as the damage occurs. Many users have little or no understanding of the function of earthing and are unlikely to consider anything but a failure of appliances to work as a fault.

At the time when BS1363 was introduced in 1947, many homes still had no electricity and there was still a widespread apprehension of a potentially dangerous service, if only by analogy with gas. Since then, several generations have grown up taking electrical services for granted. It could also be argued that carefully designed standards and equipment have been so successful in ensuring safety that potential dangers are avoided that they are no longer adequately appreciated. It is therefore all the more important that safety standards are maintained, and above all enforced – both in spirit and in detail.

Effective enforcement of safety standards relies on open and conscientious attitudes unfettered by vested commercial interests and a willingness to take responsibility beyond direct legal responsibilities. Safety, just like freedom, depends on constant vigilance.

David Peacock (david@plugsafe.org.uk) is a retired engineer, a member of PlugSafe, and one of the founders of FatallyFlawed, the campaign to raise awareness of the dangers associated with socket covers in the UK (www.FatallyFlawed.org.uk).
Thanks to Peter Munro MIET (FatallyFlawed).