PHILIPS RESISTANCE WELDING HANDBOOK

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FIRST EDITION

PRICE 10/6d.

Published by

PHILIPS INDUSTRIAL

(PHILIPS LAMPS LTD.)

CENTURY HOUSE · SHAFTESBURY AVENUE · LONDON · W.C.2

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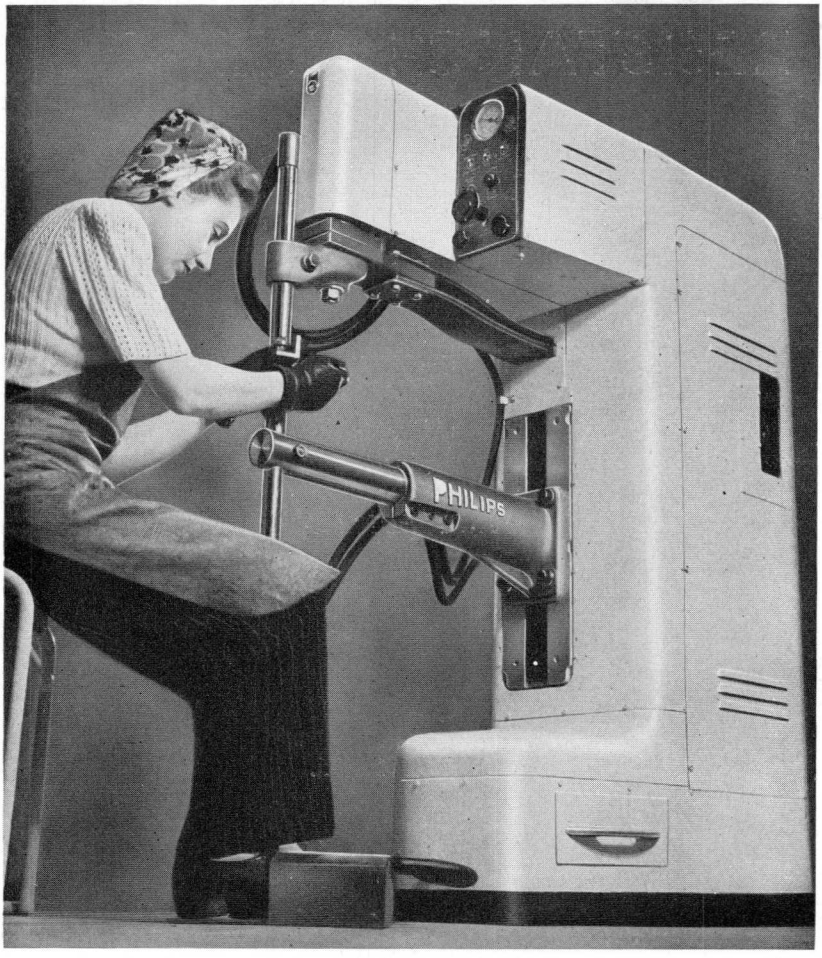

Typical example of a
modern spot welding machine.

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PREFACE

This book has been compiled to meet a need which undoubtedly exists for a practical manual on resistance welding.

It deals with the integration of resistance welding into the general process of production and is not intended to be a technical manual for the design of resistance welding machines. As such it will be of use to Works Directors, Works Managers, Engineers, Foremen and others whose interest in resistance welding lies in its practical application to the production job. It will be a valuable addition to an all too scanty library of literature of this kind. " Philips Resistance Welding Handbook " is intended as a companion volume to " Philips Practical Welding Course " which deals with arc welding. Technicalities have been avoided, although it is assumed that the reader is familiar with the principles of electricity and magnetism and has a practical knowledge of general engineering.

The collaboration of experts in the industry has been actively sought to ensure that the work covers the entire field of resistance welding and that all phases of the process are adequately covered. The ready help and generous guidance of all those who assisted in the preparation of this book is hereby gratefully acknowledged: *G. Galle, B. G. Higgins, B.Sc., A.M.I.E.E., A. J. Hipperson, B.Sc., W. S. Simmie, B.Sc., A.M.I.E.E., J. M. Sinclair, M.B.E., N. A. Tucker, A.*1 *Electric Welding Machines Ltd., British Federal Welder & Machine Co. Ltd., British Thomson-Houston Co. Ltd., Buck & Hickman Ltd., Contactor Switchgear Ltd., Ingranic Electric Co. Ltd., The Institute of Welding, Mallory Metallurgical Products Ltd., New Process Welders Ltd., "Sheet Metal Industries," and La Soudure Electrique Languepin.*

CHAPTER I

SPOT, PROJECTION AND GUN WELDERS

General Definitions—Spot Welders—Spot Welder Ratings—Stitch Welders—Gun or Pinch Welders

RESISTANCE WELDING.

Resistance welding is a mechanised form of forge welding and can be described as a modern development of the art of the blacksmith (See chart on welding methods, page 207). Perhaps the process can best be defined as joining metals by pressing them together and heating the parts adjoining the place of contact by the passage of current through the contact resistance of the joint.

From this basis a whole range of machines has been evolved, from the simple spot welder used for thin sheet metal to the large flash welder capable of welding sections of many square inches, but the principle involved is basically the same in every case.

The principles employed in a simple spot welder are indicated in Fig. 1 which shows the primary and secondary windings of the transformer, the movable and fixed electrodes, and the work pieces to be joined together.

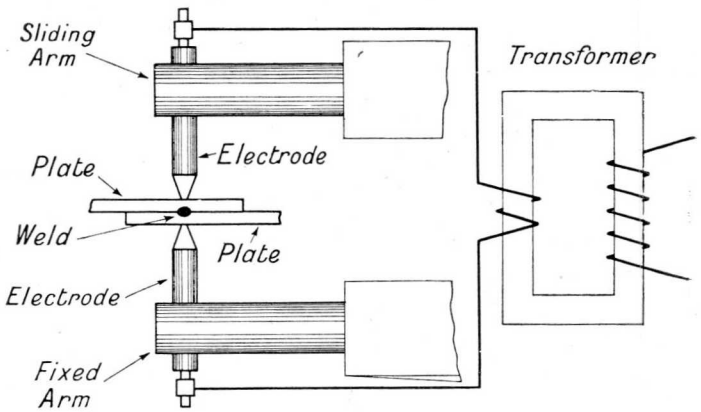

Fig. 1. Diagram of simple spot welder.

In the welding operation a current at mains voltage flows through the primary winding of the transformer inducing a secondary voltage of 2-8 volts in the secondary winding. One of the electrodes is fixed, usually the lower one, whilst the other is movable. These are closed on the work piece under pressure and for a pre-determined length of time the current heats the material and the pressure of the electrode tip forges the weld.

This, basically, is the method of operation of all spot welding machines, but so as to make the process suitable for practical operations, a number of refinements and methods of control are introduced.

The first type of machine to be described is a spot welder of the bench or floor type. This machine is provided with a single-phase transformer having a number of primary current tappings known as " heating speeds " and a secondary output of 2-8 volts. The arms are operated by a simple mechanical movement, either by hand-lever or, more often, by foot pedal. A suitable spring pressure device is fitted and the time is either controlled by an adjustable trip switch or automatically by a timer. Other types of spot welders are operated either by pneumatic or hydraulic pressure, or they are motor-operated. They are described in greater detail in the section dealing with spot welders.

Spot welders having arms separate from the transformer are known as gun or pinch welders and these are also described in detail in the appropriate section. Generally speaking the difference between a gun and a spot welder is that in the former case the welder is taken to the work whereas in the latter the work is taken to the welder.

The stitch welder is a spot welder having mechanically operated arms, generally driven by electric motors, to produce a large number of spots in close proximity, giving a sewing machine effect. The principle involved in this machine is of course identical with the single spot welder, but the mechanical details and method of construction vary considerably.

Another development of the spot welder is the projection welder (Fig. 2) in which a number of projections are raised on the workpiece. The following can be taken as a definition of projection welding : a resistance-welding process for joining metal parts, at least one of which has been provided with projections which form the only points of contact between the parts. During the welding process these projections are generally collapsed.

The next type of machine is known as the seam welder (Fig. 3) which differs from the spot welder in that instead of the electrodes being fixed with the current always flowing through the same contact points, a pair of rollers is used between which the work passes. These rollers can be either manually, mechanically or electrically operated ; usually one roller only is driven. The definition of seam welding is as follows :—A spot-welding process in which a series of consecutive spot welds can be made without manipulation by the operator (other than moving the workpiece along between the electrodes) for each individual spot-weld. One or both welding electrodes may have the form of contact rollers.

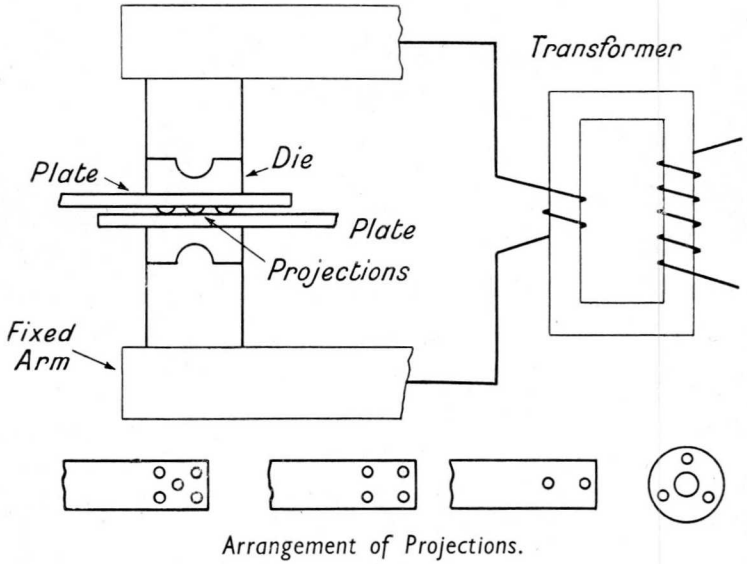

Fig. 2. *Illustrating the principle of projection welding.*

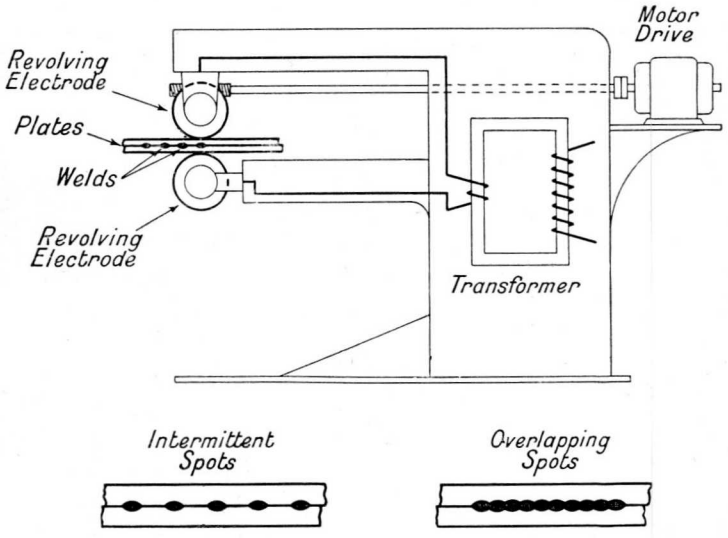

Fig. 3. *Illustrating the principle of seam welding.*

The next type of machine is known as a butt welder (Fig. 4) and butt welding can be defined as follows :—A resistance welding process in which the parts are butted together and pressure at the place of contact is maintained until the weld is complete. Butt welders are either manually

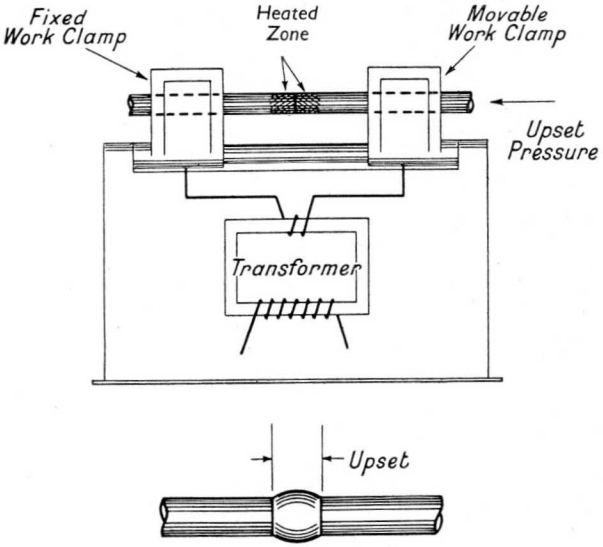

Fig. 4. The principle of butt welding.

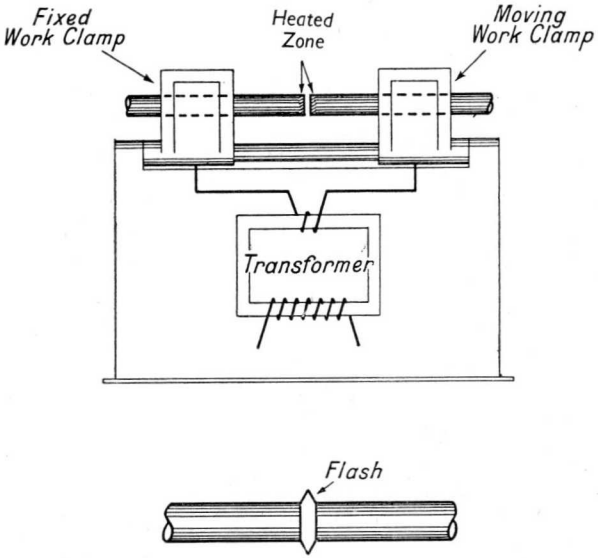

Fig. 5. The principle of flash-welding.

operated or power driven by means of electric motors, or they are hydraulically or pneumatically operated ; but whatever the method of operation, the principle remains the same.

Closely allied to the butt welder, but with a somewhat different sequence of operation, is the flash welder (Fig. 5) and flash-welding can be defined as follows :—A resistance welding process in which the contact resistance is kept at a high level, by applying a small pressure (welding pressure) during the period in which current passes. After the temperature of the parts adjoining the place of contact has reached a suitable value, the current is switched off, and the pressure between the parts to be joined is increased (forging pressure).

Whilst the details of operation are different for each of the main types of machines dealt with here, the basic principles of operation remain the same, namely, the use of high currents and low voltage to heat the material and the employment of pressure to forge the material together.

The following are the chief factors which determine the capacity of a machine, and they can be varied according to the gauge and type of material which the machine is designed to weld.

Secondary voltage (generally 2-10 v. except in special cases).

Secondary current (varying from a few hundred amps. to many thousands).

Time of current flow (varying from less than $\frac{1}{2}$-cycle of the A.C. supply to one minute).

Pressure on material (varying from a few lbs. to several thousand lbs.).

Resistance welding offers an ideal method where a large number of parts have to be welded, particularly for light material, although it must not be thought that only sheet metal is suitable for resistance welding. Machines, such as heavy flash welders, have been built to deal with 15 sq. in. material ; also large butt welders for dealing with heavy steel plate. Sometimes it is found that both resistance welding and arc welding of sheet metal and of heavier steel plate can be efficiently and economically combined.

Resistance welding also has the great advantage that unskilled labour can be used, which is an important consideration. It is also particularly suitable for female labour, and as many thousands of women are now employed as resistance welders the question of female labour is dealt with in some detail in Chapter XIII.

In the following pages the main types of modern resistance welding machines are dealt with in greater detail, and in this connection one point should be emphasised. Whilst earlier types of machines operated on the same basic principles, considerable technical advances have been made in design and methods of construction in recent years. If, therefore, unsatisfactory results have been obtained in the past, resistance welding should not be dismissed as unsuitable for any particular application until the problem has been examined in the light of present day knowledge, and with regard to the results which can be obtained with modern equipment.

SPOT WELDERS.

A spot welder is a machine for making individual welds between two or more pieces of metal consisting of either separate or overlapping spots.

The method of operation of a typical spot welding machine is as follows (see Fig. 7) :— When pedal A is depressed, the moving arm B is lowered and the electrodes are brought in contact with the workpiece. When pressure is applied the contactor is closed and the current flows between the points ; the workpiece is heated and the pressure forms a weld referred to as a " spot weld." When pedal A is released the current is broken by the contactor and the electrodes are parted to enable the work to be removed.

The following detailed description of this type of machine will be more readily understood if reference is made to the numbered diagram, Fig. 7.

(1) **The body or casing of the machine.** In older types of machines this was of cast iron, but most modern machines are built with a steel frame with sheet metal casing or with a welded steel plate body.

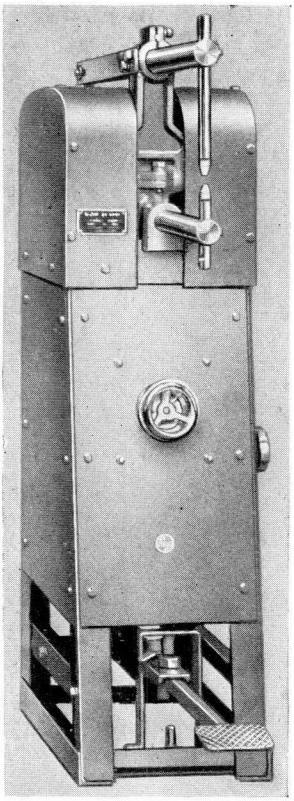

Fig. 6. Modern type of manually operated spot welder.

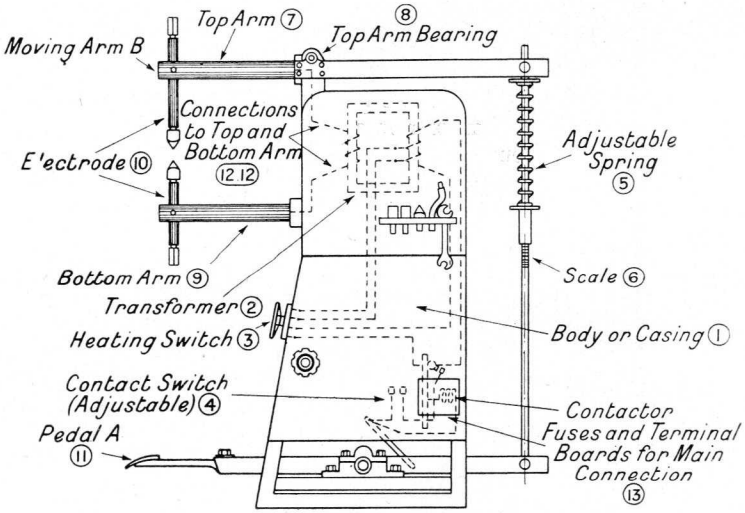

Fig. 7. Diagram of spot welder showing method of operation.

(2) **The transformer.** This consists of a single-phase primary winding suitable for mains voltages, and is generally arranged so that the machine can be connected to 400 or 440 v. supply. It is fitted with a number of current taps known as heating speeds. The transformer used in this type of machine is always single-phase. A heavy secondary winding with a voltage output of 2.8 v. is fitted, which is usually a single turn of heavy section. The transformer is generally of the single coil primary type with single loop secondary and air-cooled. In larger machines the secondary winding is sometimes water-cooled.

(3) **The heating speed or tap switch.** This is generally operated by a hand-wheel and gives a number of heating speeds. This hand-wheel turns an arm which makes contact with studs to which the primary tappings are connected.

(4) **The contactor or trip switch.** In the case of a contactor operated machine a relay (4) closes the contactor circuit when the pedal is depressed.

When a trip switch is used, the sequence of operation is slightly different. When the pedal is depressed, the trip switch closes and the mechanism of the switch is such that it remains closed for a short period which may be varied by adjustment, after which the spring or mechanical trip opens the switch ; thus the welding current is arranged to flow for a given period, according to the nature and thickness of the work.

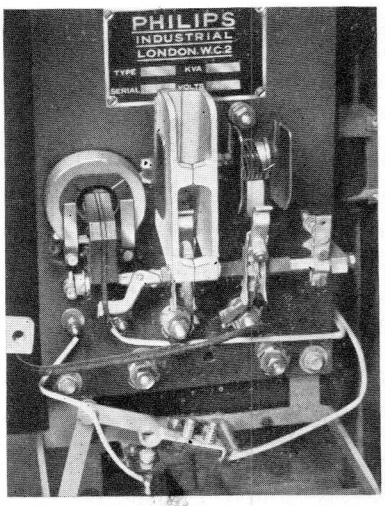

Fig. 8. Contactor relay switch.

(5) **The spring which affords variation of pressure on the work-piece.** This is generally accomplished by means of a collar and a knurled and serrated nut, the adjustment of which alters the spring pressure.

(6) **A scale which indicates the point of adjustment.** In some cases this is marked in lbs., but on most machines it is provided with divisions so that the spring pressure can be adjusted to a known point.

(7) **The top arm.** This moves on the bearing (8).

(8) **The bearing for the top arm.** This is generally either white metal or gunmetal lined.

(9) **The bottom arm.** This, in the machine illustrated in Fig. 9, is of the fixed type, but in some types of machines it is fitted to a face plate so as to permit adjustment in all directions.

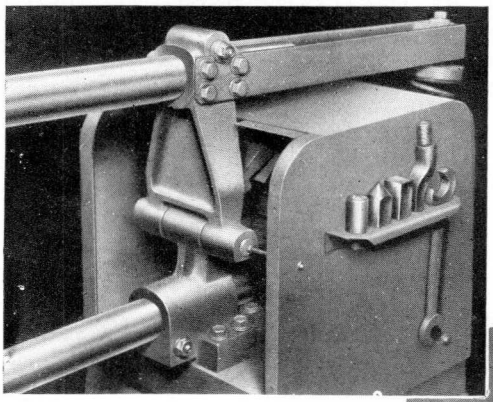

Fig. 9 (left). This machine has cotter type fixing of all moving parts ; thus split collars are avoided and dirt is excluded from the secondary connections

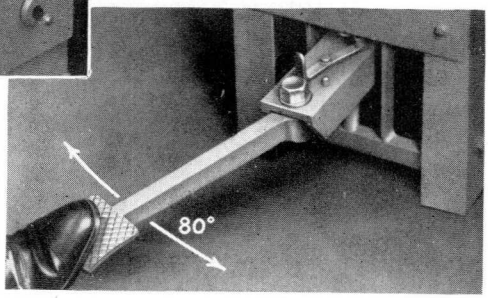

Fig. 9a (right). In this machine the foot pedal can be adjusted to any position in an arc of 80° to left and right.

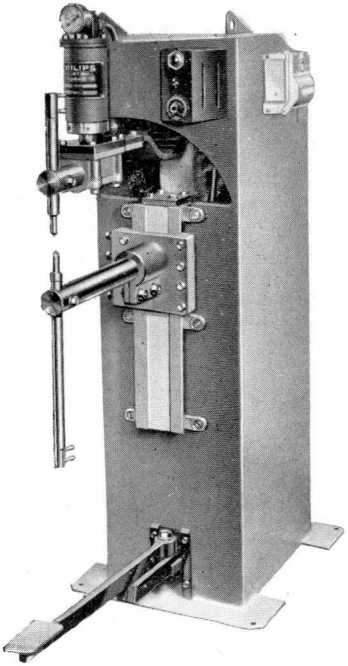

Fig. 10

(10) **The electrodes or stakes.** In smaller machines these are sometimes solid, but in most modern machines they are water-cooled and fitted with removable tips or points.

(11) **The foot pedal.** This is for operating the machine. In the type illustrated in Fig. 9a it is adjustable in the horizontal plane.

(12) **Secondary connections.** These are the connections from the transformer to the arms. On most types of machines they consist of flexible copper laminations.

(13) **Fuses and terminal boards.** Used for mains connection.

This type of spot welder has been described and illustrated in some detail as, if the operation and principles are thoroughly understood, the methods of operation of larger and more complicated machines will present no difficulties, and it will not be necessary to repeat in detail the first principles.

One of the latest types of manually operated spot welders, instead of em-

ploying mechanical leverage, employs hydraulic operation (Fig. 10). This machine operates basically in a similar manner to the mechanical leverage machine previously illustrated, but has definite operational advantages over previous types, since the wearing parts are reduced in number, the effort required from the operator is reduced and accurate control of pressure can be obtained.

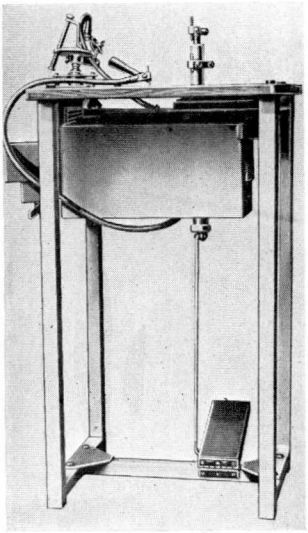

Fig. 11.

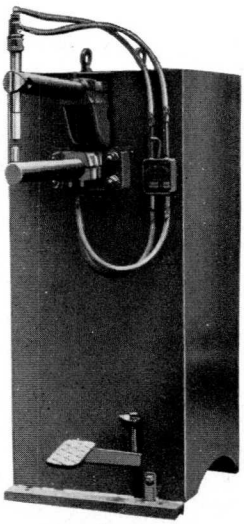

Fig. 12.

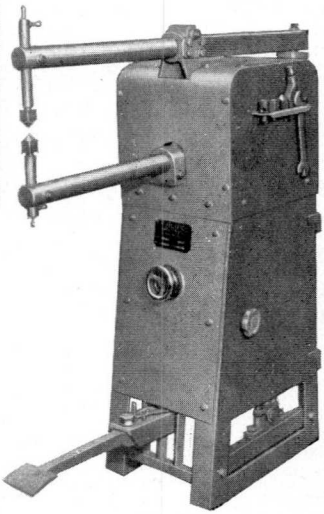

Fig. 13.

4, 14 and 20, kVA spot welders

Figs. 11, 12 and 13 illustrate typical examples of the wide range of manually operated spot welders in the market. It must, of course, be realised that machines can be supplied with longer or shorter arms, but as the arm length increases, so the welding output decreases and a machine with excessively long arms generally means slow operation and increased mechanical effort.

For sizes above 25 kVA., mechanically, pneumatically or hydraulically operated machines are mostly supplied and therefore the next step is to describe the operation and arrangements on various types of spot welders which are built in a range of sizes from 25 kVA. upwards, a very usual size being 40 or 50 kVA. Large sizes such as 75, 125, 180 and 250 kVA. are made, but these last-named and larger sizes are more often used for projection welding and are described in the chapter dealing with that subject.

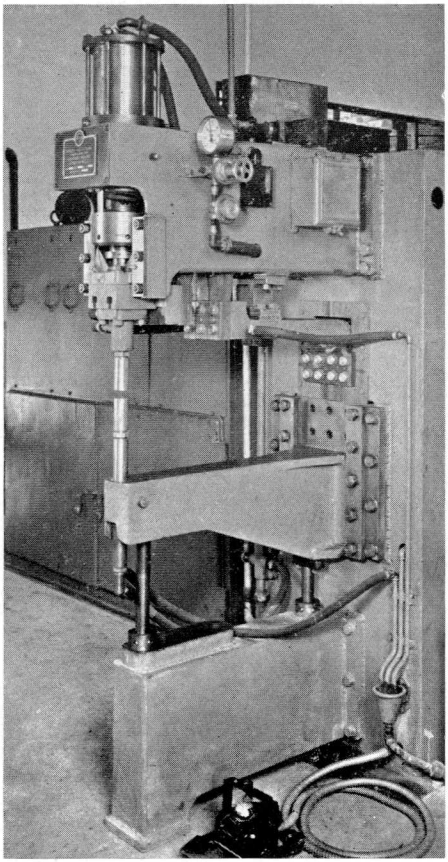

Fig. 14. A modern example of a pneumatically operated spot welder.

The system of operation is practically identical with the manually operated machine except that pneumatic power is used, the air pressure being 60-120 lbs. per sq. inch.

The system usually employed is that of providing a piston operated by compressed air to operate the movable electrode directly. When the electrode pressure on the workpiece reaches a pre-determined value or the electrode is moved a pre-determined distance, a contact is closed which brings a relay switch into operation causing the current to flow. In those machines which are fitted with a timer the current flows for a definite period of time, usually so many cycles of the supply frequency or a number of seconds.

Most machines of this type are so arranged that the pressure can continue to be applied or increased after the welding current ceases, to give a forging effect. The piston is then either returned pneumatically or by means of a spring to the starting position. In the pneumatic type air is admitted on the under-side of the piston ; in the spring type a strong spring returns the electrode when the air relay switch releases the pressure either at a pre-determined length of travel or at a pre-determined pressure

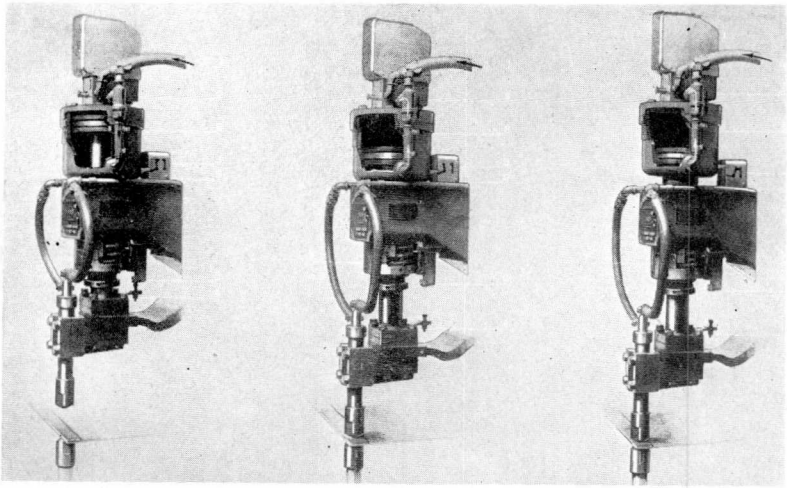

Fig. 15. A modern pneumatic spot welder head showing piston in position.

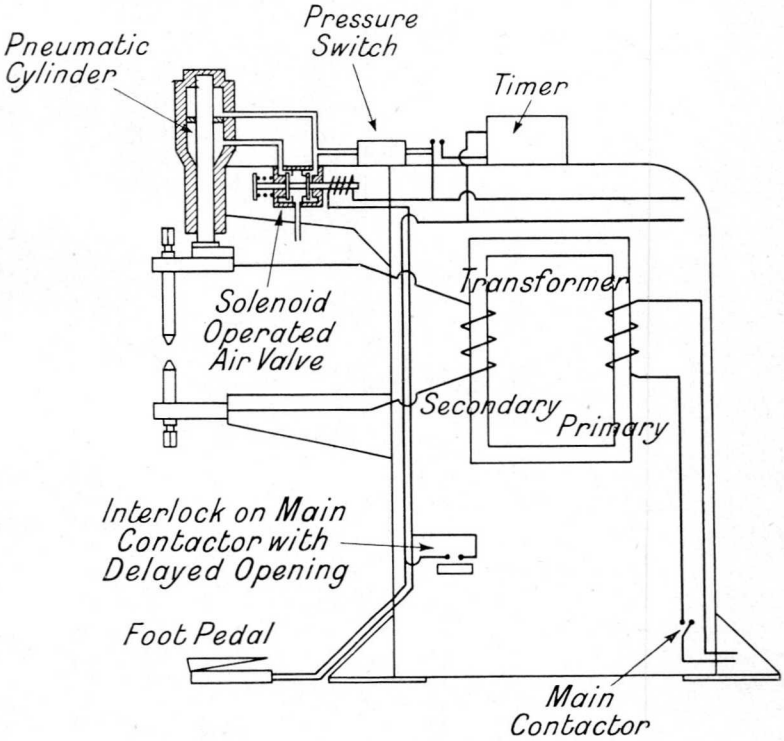

Fig. 16. Diagram showing layout of a pneumatic spot welder.