SUPPRESSION OF INTERFERENCE AT THE SOURCE

General Principles

1. General.—This Instruction describes the principles upon which interference suppression at the source is based. Various basic arrangements of suppression components are illustrated, and their application in given circumstances is explained. The question of shielding is also dealt with in some detail in pars. 12 to 19 for completeness, though the deliberate provision of shielding is seldom necessary to abate interference caused by ordinary electrical apparatus. Shielding may, however, be vitally important in special cases, e.g. radio-frequency equipment used for industrial, scientific, and medical purposes.

2. The nature and origin of interference is dealt with in B 1005, and B 1020 deals with the general principles of interference suppression at complainants' premises.

3. Definitions.—The following definitions have been adopted for the purposes of this Instruction :—

Interference. The confusion of a desired radio signal by the effects of domestic or industrial electrical appliances, machinery, or installations.

Noise. The unwanted energy (radio-frequency voltages and currents), usually of random character, generated in certain classes of electrical appliance and in the wiring connected to them.

Noise currents or voltages. Currents or voltages in the radio-frequency spectrum caused by abrupt changes in the electrical condition of a circuit. The more abrupt the change the higher will be the frequency to which components of the noise currents or voltages extend.

Noise field. The region permeated by electromagnetic waves caused by abrupt changes of current in an electrical circuit.

Field strength. The intensity of an electromagnetic field expressed as the voltage which would be induced in an aerial having an effective height of one metre.

4. Maintenance of plant suspected of causing interference.—Unsatisfactory maintenance may cause or increase interference, especially when plant has been in use for some time. Severe interference caused by a commutator motor may, for instance, be lessened by improving the condition of the commutator and brush-gear. Intermittent disconnexions or haphazard earths on electrical installations are likely causes of interference. It is desirable, therefore, to examine the plant, and to put right such matters as these before applying suppression devices.

5. Approach to suppression.—Interference with radio reception may be abated in the following ways :—

(*a*) By reducing the noise voltages and fields at their origin

(*b*) By attenuating the noise currents and fields in the course of their propagation.

Method (*a*) has only a limited application, which is in general restricted to simple types of make and break mechanisms. Method (*b*) involves the attenuation of direct radiation of noise energy from the source and its wiring, and the attenuation of noise voltages and currents propagated along conductors connected or coupled to the source. This may be accomplished by using a combination of an electromagnetic shield and radio-frequency filters.

PREVENTION OF GENERATION OF NOISE

6. Principle of method.—Noise energy is generated when potentials or currents in an electrical circuit change suddenly. If, then, these changes can be sufficiently slowed down, noise energy will not be generated. Figs. 1 to 4 show noise suppressor circuits which work on this principle, and which introduce sufficient damping of the noise energy, though not always preventing its generation.

7. *Capacitor across contacts (see Fig. 1).*—Noise generated by the operation of switches can be reduced by connecting a capacitor immediately across the switch contacts. The value of C depends to a large extent on the value of the current and the nature of the load. A capacitance greater than about 0·1 μF. may cause welding of the contacts due to the instantaneous discharge of the capacitor on ' make '. This effect will be more serious in medium-voltage and high-voltage (i.e. 250 volts or more), low-current circuits in which the surface area of the contacts is usually small. The use of a spark-quench circuit overcomes this difficulty (see par. 8).

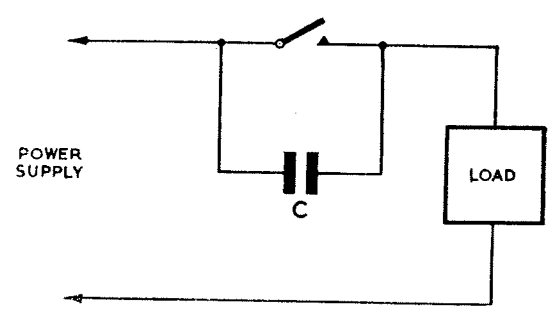


FIG. 1.—CAPACITOR ACROSS CONTACTS

Distribution :—67

8. *Spark-quench circuit* (*see Fig. 2*).—Many thermostatically controlled devices such as electric smoothing irons and bedwarmers are fitted with a slow-acting switch. Each time the switch operates, arcing occurs, and a buzz is heard from the loudspeaker instead of the click which is normally associated with the operation of a simple switch. This arcing can cause excessive wear of the switch contacts, and a spark-quench circuit comprising a capacitor (C) and resistor (R) in series may be connected across the contacts to reduce the arcing. By reducing the arcing the spark-quench circuit tends to change the interference from a drawn-out buzz to a click. The click is less annoying than the buzz, and in this way the spark-quench circuit may be said to behave as a suppressor. The action is, however, different from that of orthodox suppressors in that it does not, in general, reduce the peak amplitude of the noise voltages and fields, but changes the character of the noise.

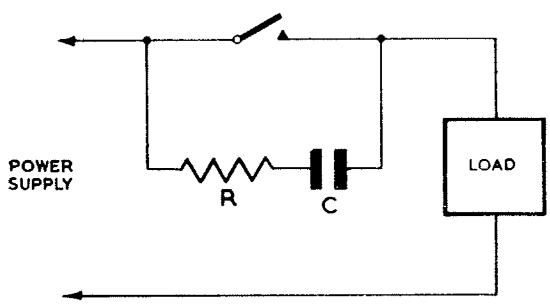


FIG. 2.—SPARK-QUENCH CIRCUIT

9. *Series connected inductors with capacitor in parallel* (*see Fig. 3*).—Although more expensive, this arrangement is very effective. The rise and decay of current in the circuit are opposed by the self-induced E.M.F.s which appear instantaneously across each inductor (L).

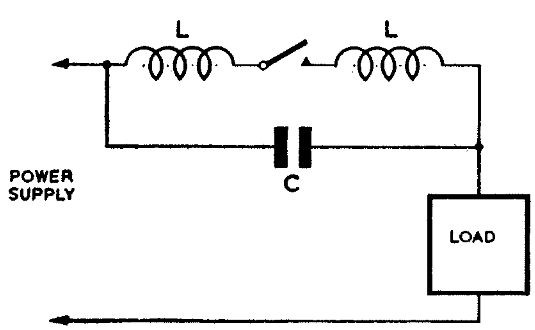


FIG. 3.—SERIES CONNECTED INDUCTORS WITH CAPACITOR IN PARALLEL

10. The use of long capacitor leads is equivalent to the addition of inductance in series with the capacitor, and tends to nullify the slowing-down process ; the use of long inductor leads increases the possibility of direct radiation. The suppressor should, therefore, be mounted as closely as possible to the source and the connecting leads should be kept as short as is practicable.

11. *Resistor* (*see Fig. 4*).—The use of resistors as a preventive measure is normally limited to high-voltage installations such as ignition systems of internal combustion engines and oil-burning furnaces. Without a resistor in the circuit formed by the H.T. coil (or magneto), distributor, plug-lead and chassis, the current may reach high instantaneous values. With a resistor (about 10,000 ohms) connected in series in the circuit the transient current becomes non-oscillatory and its crest value is reduced.

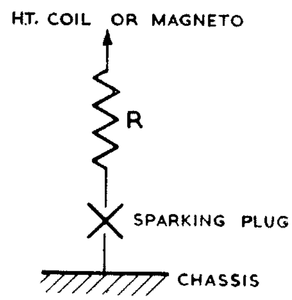


FIG. 4.—SERIES RESISTOR

PREVENTION OF PROPAGATION OF NOISE ENERGY

12. Basic considerations.—It is theoretically possible to prevent the propagation of noise energy from any source by means of an electromagnetic shield and radio-frequency filters. The principle is illustrated basically in Fig. 5 ; the shield prevents the direct radiation of energy from the source (see pars. 13 to 18) and the filter stops the noise currents from spreading along the power lines (see pars. 20 to 23).

13. *The ideal electromagnetic shield* would be a complete enclosure of continuous metal sheet so constructed as to have zero impedance under all conditions between any two points on its surface. The efficiency of a shield decreases progressively as the design departs from this ideal, whether by using inferior material or by having high-impedance joints between sections of the material. Discontinuities in the shield reduce the attenuation afforded by it more than does the use of unsuitable material.

14. *Joints and removable sections in shields* are, however, unavoidable ; where they occur, continuous electrical contact should be made along the entire

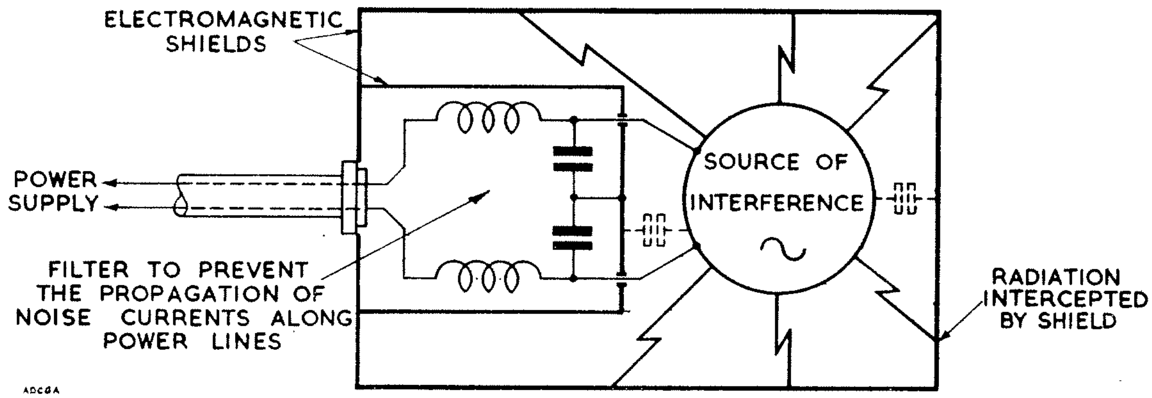


FIG. 5.—BASIC PRINCIPLES OF NOISE SUPPRESSION AT SOURCE

length of each joint. If this is not practicable, a number of point contacts equally spaced along the line of joint is preferable to the equivalent contact surface area concentrated at one point.

15. Principles of electromagnetic shielding.—At radio-frequencies magnetic shunting becomes negligible ; attenuation of the radio-frequency field is due entirely to the currents induced in the shield material, and may be divided between the following cumulative effects :—

(*a*) Attenuation due to currents induced around the circumference of the shield. This may be regarded as a short-circuited transformer action, or reflexion loss

(*b*) Attenuation due to eddy currents induced in the thickness of the shield material, i.e. skin effect, or transmission loss.

16. When the shield is made of continuous metal sheet, attenuation due to skin effect will increase as the frequency is increased ; but when there are discontinuities in the shield material, skin effect accounts for much less attenuation, and the attenuation decreases as the frequency is increased.

17. *Earthing the shield* contributes nothing to the attenuation of the radiated field, but it may be essential in the interests of safety and to prevent any sensation of shock.

18. Economics of shielding and filtering.—On economic and practical grounds it is seldom possible to shield completely both the source and all the wiring connected to it (most sources of interference are worked from the public electricity supply) ; shielding is, therefore, restricted to the vicinity of the source, and radio-frequency filters are fitted in the supply wiring to prevent the noise energy from spreading over the power lines to radio receiving installations in the neighbourhood. The degree of attenuation achieved by the shield and the filters should be about equal.

19. Self-shielding of electrical appliances.—It is seldom necessary to incur the expense of a special shield to attenuate noise energy caused by the majority of domestic and industrial electrical appliances ; the metal frame or carcase of such appliances is a partial, if not a complete, shield, and is usually sufficient for the required purpose. The use of special electromagnetic shields applies more particularly to radio-frequency equipment used for scientific, industrial, and medical purposes (see C 2201).

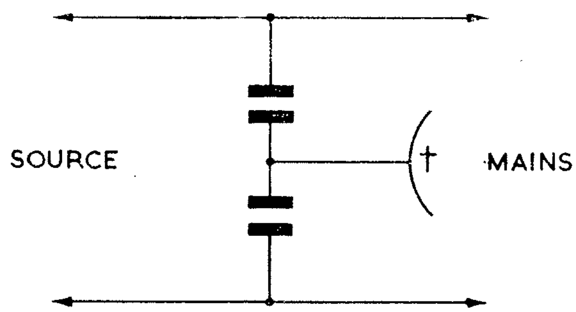
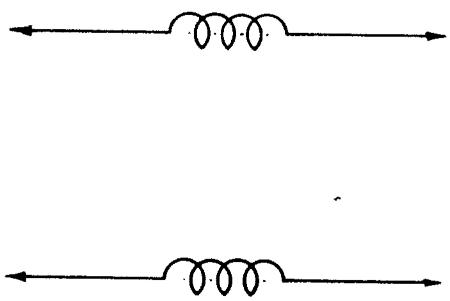
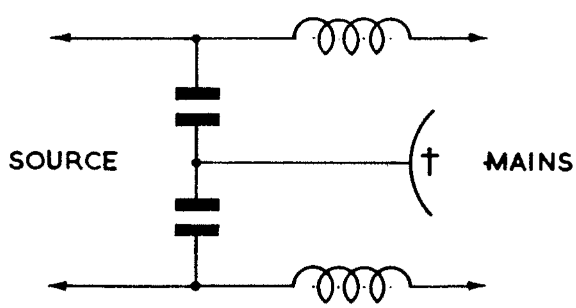
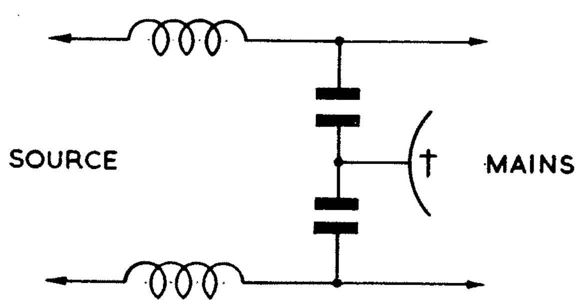
20. Prevention of propagation of noise energy along wires.—Radio-frequency currents are propagated along wires in two ways :—

(*a*) *Symmetrically*, i.e. along one conductor, returning to the source by another

(*b*) *Asymmetrically*, i.e. in the same direction, simultaneously, along the mains conductors, returning to the source via the distributed capacitance to earth of the conductors, and either the capacitance to earth of the appliance, or the earth lead, if one is fitted.

21. Noise currents and voltages may be attenuated by fitting a radio-frequency filter in the wiring of, and at a point as close as possible to, the source of interference. A suitable filter would be one consisting of low-impedance elements (capacitors) connected from the conductors to the metal shield, carcase, or frame of the source, and also between the conductors, or of high-impedance elements (radio-frequency inductors) connected in series with the conductors, or of a combination of both types.

TABLE 1

Impedance of		Basic Circuit of Noise Suppressor	Remarks
Source	Mains		
High	High		See par. 24.
Low	Low		Useful at V.H.F. and for high-voltage installations, e.g. dust precipitators.
High	Low		Two or more suitably designed filters may be connected in series to protect separate frequency bands, e.g. the broadcast and television bands.
Low	High		As above.

† Capacitors should be connected directly to the metal frame of an appliance, or to the metal shield of a shielding enclosure, whether the item is earthed or not.

22. The type of filter necessary in any particular case depends on :—

(*a*) the attenuation required ; this is determined by

(i) the magnitude of the noise voltages and currents impressed on the mains conductors by the source

(ii) the extent to which this noise energy is attenuated on its way to the aerial of the affected radio receiver

(iii) the field strength of the desired radio transmissions in the locality of the receiver

(iv) the tolerable signal to noise ratio

(*b*) the impedance characteristics of the appliance and the mains.

23. If the impedances of the source and the mains are high, appreciable attenuation would be given by capacitors alone ; if both impedances are low, inductors alone would be useful. Basic circuit arrangements of filters for various source-mains impedance conditions are shown in Table 1. For the characteristics and design requirements of filters see E 0030.

24. With certain classes of appliance the efficacy of capacitors alone as suppressors, particularly at low radio-frequencies, is limited by a restriction for safety reasons of the maximum value of capacitance which may be connected to the frame of the appliance. Portable appliances, for instance, will require the addition of series inductors to supplement the action of the capacitors (0·005 μF. max.) in attenuating the asymmetric components. Information on shock hazard, earth leakage, and safety considerations is given in E 0005.

25. Details of the suppression arrangements applicable to specific sources of interference are given in C 2000 to C 3999.

26. Observance of I.E.E. Wiring Regulations.—An interference suppressor intended to be connected to the electricity supply mains should be constructed to comply with the current issue of the "Regulations for the Electrical Equipment of Buildings" issued by the Institution of Electrical Engineers, and with relevant British Standard specifications and Codes of Practice.

References :—B 1005, B 1020, C 2201, E 0005, E 0030
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END

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