Ignition Interference to FM and Television

Exhaustive measurements show the effects of automobile interference on reception and ways of preventing it

By JOHN B. LEDBETTER*

WHILE the effects of interference from automobile ignition systems on radio and television reception are well known, the exact process through which they are brought about is not as familiar. A sound basic knowledge of the contribution of each part of the ignition system to the generation and radiation of interfering electrical pulses is necessary for a logical approach to the problem.

We usually think of the electrical system of motor vehicles as handling low-voltage direct currents. There are several points, however, in the ignition system where high-frequency, high-voltage oscillations exist. At any point where an arc is generated, a transient oscillating current flows in certain parts of the wiring. Such arcs occur under certain conditions at the generator brushes, starter motor, heater fan motor, and at the breaker points of any of the relay devices, such as the voltage regulator.

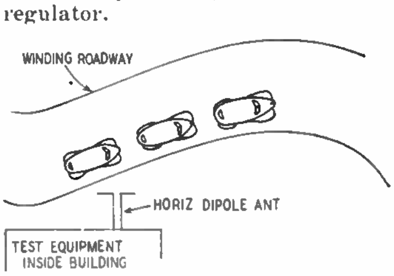

Fig. 1—Cars drove slowly away from antenna.

In the ignition system, high-frequency oscillation takes place in the primary circuit when the breaker points open, even though an arc does not actually form. This is due to the rapid change of current in the primary, which causes a correspondingly rapid change in the magnetic flux linking the primary and secondary of the ignition coil. As the magnetic flux collapses through the secondary winding, it induces a very high voltage in that circuit, which ionizes the electrodes of the spark plug and causes the spark to appear.

The spark, or instantaneous secondary discharge, has a *capacitance* component of approximately 1 microsecond duration and a peak current up to 150 amperes. The discharge of the capacitance component, which oscillates at very high frequencies, is followed by an *induction* component of much longer duration and much lower current value. The current, which decreases exponentially during this period, has superimposed on it sine-wave oscillations whose frequency depends on the L-C properties of the primary circuit, that is, the frequency of resonance.

It is the extremely high-frequency, high-current discharge in the *capacitance* component of the spark which results in outward radiation of electromagnetic waves from the high-tension ignition system. Because this radiation does not confine itself to any fixed frequency but occurs at many different frequencies, and at greatly varying amplitudes, interference is caused to almost every type of radio broadcast and communications service, especially those operating in the higher-frequency bands.

Suppression at the source

Although directional receiving antenna systems can be employed to good advantage in discriminating against uncontrolled radiation from a parallel plane or fixed source, they become rather ineffective if interference is received from several different directions. The only logical answer to the problem, therefore, is the suppression of ignition interference at its source, or its reduction to a tolerable limit.[1]

The Radio Manufacturers Association has taken steps toward a practical solution of the problem. A meeting was called in February, 1944, between the RMA and the Society of Automotive Engineers, and a joint RMA-SAE Committee on Vehicle Radio Interference was organized. Three subcommittees were formed, and each was given a specific assignment in the interference study.

In 1944, the receiver subcommittee made exhaustive tests to determine the tolerable limits of interference of several makes of FM receivers. The first field test was made at Rye, N. Y., where several different makes of FM and television receivers were set up to receive broadcasts from NBC and CBS in New York City. Conditions were controlled so that the received signal strength at Rye would approximate the fringe-area value of 50 microvolts per meter for FM and 500 microvolts per meter for television.

The measurement setup consisted of a horizontal receiving dipole mounted 7½ feet above the ground and connected to the various receivers, and a Measurements Corporation Model 58 noise meter. With the receivers tuned in, different makes of motor vehicles were driven slowly away from the receiving antenna until a point of tolerable interference (as determined aurally or visually by a committee of three) was reached. (See Fig. 1.) The noise meter was then connected to the antenna and the strength of the interfering radiation was measured.

As a result of these tests, a field strength of 35 microvolts per meter at a distance of 50 feet from the distributor-coil side of the vehicle was fixed as the tolerable limit of interference. This limit is applicable at all frequencies up to 150 mc.

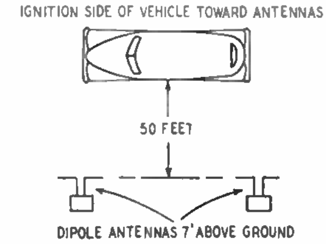

Fig. 2—Noise measurement setup used at Rye.

[1] "The Automotive Industry's Participation in Reduction of Radio and Television Interference," P. J. Kent, Chief Engineer, Electrical Div., Chrysler Corp. Paper presented at SAE summer meeting, French Lick, Indiana, June 6-11, 1948.

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A second test

In June, 1944, the RMA-SAE interference committees conducted the second field test at Anderson, Indiana. For the test, seven different makes of automobiles were selected as being representative of the engines and electrical systems in common use. The noise-meter antenna was set up for both horizontal and vertical polarization at distances of 5, 15, and 50 feet from the ignition side of the vehicle. Each vehicle was equipped with the suppression supplied or recommended by the manufacturer; in many cases different types or amounts of suppression were employed to determine their effectiveness.

Some general conclusions were reached as a result of this series of experiments:

1. Vehicles employing compactly grouped ignition systems produce less interference than those in which components are more widely separated from each other.

2. Spark-plug and distributor suppressors are more effective below 40 mc than above, although interference is reduced considerably at the higher frequencies.

3. A very effective method of suppression is to completely enclose the ignition system in a grounded metal shield and employ spark-plug and distributor suppressors.

4. Measurements of radiation intensities made by different methods and with various instruments do not necessarily agree.

5. Generator interference, when present, was noticeable at a distance of 5 feet but not at 50 feet.

6. Interference resulting from a group of vehicles is *less* than the total of the individual vehicles (possibly due to phase cancellations).

7. Radiation from any given vehicle varied widely at a number of different frequencies.

Another series of field tests was made at Anderson in 1945 to determine which type of suppression would work best with each type of vehicle. For this test 13 passenger cars and trucks were used, and the standard Rye measurement setup was used (see Fig. 2). Note the radiation curves (Fig. 3) of a typical six-cylinder engine with two degrees of suppression. The addition of spark-plug suppressors is obviously important.

The conclusions

Several conclusions were reached:

1. The majority of vehicles are capable of meeting the tentative tolerable limit (35 microvolts per meter at 50 feet, measured on a horizontal antenna 7½ feet above ground) by employing 10,000-ohm suppressors at each spark plug and in the distributor center lead, and by locating the ignition coil so that the high-tension lead (from coil to distributor) is not over 8 inches in total length.

2. Addition of a capacitor on the primary lead *at the coil* is necessary in some cases.

3. All high-tension leads should be kept as short as possible.

4. All metal tubing, rods, coolant lines, and wiring other than ignition should be kept well away from the ignition system.

5. No excessive interference from electrical equipment other than ignition was noted at the 50-foot distance, although the possibility of such interference does exist.

A third series of field tests was conducted at Anderson in August, 1947, mainly for the purpose of educating automotive personnel who had not seen the previous tests.

Another set of tests

The fourth set of field tests, made expressly to determine the effect of ignition interference on modern television receivers, was conducted at Marlton, N. J., approximately 15 miles from Camden, where a signal strength of 500 microvolts per meter at 7½ feet above the ground could be obtained from WFIL-TV, Philadelphia.

The measurement site was located in an open field, removed from interference except for the vehicles to be measured. The television receivers and the noise meter were placed in darkened area for proper viewing of the C-R-tube screen.

The cars under measurement were driven head-on toward the antenna site until the observers agreed on a tolerable value of interference. For each measurement, the engine was run at the speed which resulted in the greatest amount of interference (usually a repetitive acceleration).

The conclusions were:

1. Interference from ignition systems causes a tolerable black or black-and-white streak in the picture at an interference level varying from 6 to 69 microvolts, depending on the character and duration of the radiated pulse as well as on the receiver. The average limit of tolerable interference for all measurements on the four receivers was approximately 33 microvolts. (This agrees remarkably well with the 35-microvolt level of tolerable interference set up in the Rye tests.

2. The television receivers did not lose synchronization when subjected to the so-called tolerable limit of interference.

3. The character and duration of the radiated pulse as seen on the television screen determines to some extent the tolerable level of interference. For example, the long, serrated pulse of a Pontiac tested was easily seen and therefore required more suppression than some others.

4. The interference level used for the tests allows satisfactory reception only if it is intermittent but does not if it is continuous interference. For satisfactory reception under continuous interference, a signal-to-noise ratio of approximately 30-40 db (for equal band width of television receiver and noise meter) would probably be required. This is a considerably better ratio than the "tolerable" ratio decided on during the test.

5. In the receivers tested, the immunity of the sound channel to interference was better than that of the picture channel, and, for all practical purposes, may be regarded as about complete.

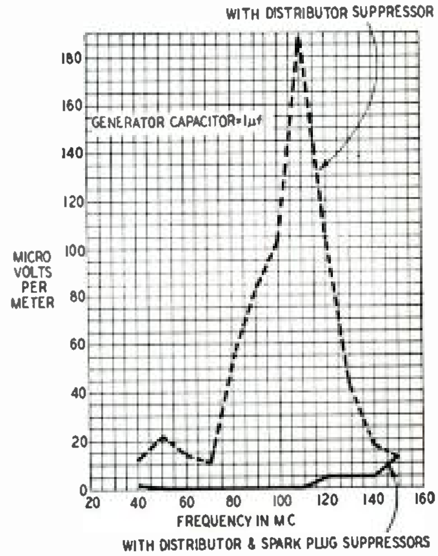

Fig. 3—Curves show suppressors are effective.

6. The 1948 Chevrolet (the only late-model car tested) incorporated certain ignition changes and was not equipped with suppressors. Its interference radiation was within tolerable limits.

7. Use of the special "resistor spark plugs" (with built-in suppressors) reduced radiation from the ignition system by an appreciable amount. In the two tests conducted with these spark plugs, the tolerable interference distance moved from 200 feet from the antenna to approximately 70 feet, a substantial gain.

Reports from numerous sources indicate that no detrimental effect on engine performance or fuel consumption is brought about by the installation of suppressor resistors. Their addition, in many cases, helps show up spark plugs which are old, coked, or partially fouled.

The ultimate result of all the tests has been to show that by the simple expedient of equipping all motor vehicles—passenger cars, trucks, and buses—with suitable suppressors (and possibly rearranging distributor wiring in stubborn cases) the problem of ignition interference to television and FM and AM radio reception can be effectively solved.

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