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SUPPRESSION OF ON-SITE INTERFERENCE AT THE ALGONQUIN RADIO OBSERVATORY

- M. MEAGHER -

OTTAWA
APRIL 1969

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Introduction

Radio astronomy at N.R.C. from 1947 - 1960 was conducted at a site near Ottawa. As the years progressed it became increasingly apparent that encroachment of civilization was the fundamental factor in the steadily increasing amount of radio interference. In 1957 the Radio and Electrical Engineering Division conducted a joint search with the Observatories Branch for a suitable site for the Dominion Radio Astrophysical Observatory. Immediately upon completion of this search, a similar one was conducted for a new radio observatory for the National Research Council. A large number of sites were investigated and the present site at Lake Traverse was chosen for its low radio noise level and for the assurance that encroachment of civilization was discouraged by the policy of the Department of Lands and Forests of Ontario.

To-day, an observatory with several million dollars invested in it exists at this site. Negligible radio interference comes from outside establishments. Considerable extra expense was involved in assuring that the hydro line would be radio noise free, yet the site is becoming increasingly plagued by interference of such a level as to make some observations very difficult if not impossible. All this interference is generated on the site, much of it due to disregard of radio interference principles and of the possibility of shielding and interference suppression.

It is not yet too late to take action. I urge that adequate suppression be obtained for all new equipment and installations. A progressive program for eliminating the worst sources of interference should be undertaken without delay. Particularly bad interference generators are the snow plough truck and cherry picker. These should be equipped and maintained with the best suppression harness available. Contactors of various kinds should be fitted with suppressors. Thermostats, particularly those directly switching considerable power, are a bad source of interference. These should be hunted down and suppressed or changed to a snap action type.

The question of ignition interference from private vehicles is more difficult. Over 100 vehicles stops and starts were recorded in one date at Site 3. Suppression of these vehicles has undoubtedly taken place with standard techniques and neither government nor individual can be expected to supply the additional suppression harness necessary for adequate suppression at radio astronomy sites. However, it should be possible to limit the number of approaches to each site, perhaps by arranging transport vehicles which could be properly suppressed. It should be noted that the D.R.A.O. operates diesel vehicles on site to keep ignition interference to a minimum. Surely if other observatories are aware of and take action to eliminate interference of this nature, then it is not too much to expect N.R.C. to protect the millions of dollars invested at A.R.O.

At the request of Dr. G. A. Miller and L. R. McNarry, noise measurements were taken in the latter part of October at Lake Traverse. A noise and field intensity meter Model NF-105 manufactured by Empire Devices Incorporated was used. This instrument measures the field strength of radio frequency signals. In our particular case the instrument was used for noise level measurements.

Carrier or peak measurements of continuous wave signals are indicated on a meter calibrated in microvolts and decibels above 1 microvolt. Noise peaks are read directly from the meter, or by the aural slide-back method. In most instances, direct meter reading was used, due to problems in the use of the head-phones. The use of this particular device was not effective in many cases. In some areas it was difficult to choose location that was free from high trees and this made it difficult to obtain a proper field strength pattern.

As was stated previously, extensive noise measurements were taken in 1957 and, although the recent survey was minor in comparison, the results should be alarming. In outlying areas no appreciable change was noticed, but the noise level increased in and around the vicinity of the sites. This will have to be regarded as "man-made" noise. As has already been stressed, many of the problems now in existence can be rectified by proper suppression. As power and sensitivity of receivers increase in the future it will be a necessity to devote considerable time

and effort in the designing stage to the interference problem. In general, a high degree of interference can be expected until planning action is taken to prevent such interference. This must include careful design of equipment, good installation, and good grounding and filtering practice.

Motor vehicles

The motor vehicles present the greatest problem in so far as noise in concerned. The ignition system, as we know, is essentially an arc system and generates both conducted and radiation interference. The interference originates at breaker points, rotor gap, spark plugs, and ignition coil. Interference of this nature can be reduced greatly by enclosing all ignition components and wiring in a properly grounded shielding harness. Since some of the interference can be conducted back to the ignition switch and its complex of low-voltage wires, it is desirable to reduce it with a feed-through capacitor or filter in the line to the distributor.

In most cases the suppression described above is sufficient, but alternator/generator regulators can give noise problems. These also can be suppressed by proper shielding, but at a greater cost. It would be to our advantage to have maximum suppression at least on vehicles that are in and around the sites quite regularly. Noise measurements on the vehicles were taken, using the dipole in a clear area. There was no

obstruction between the dipole antenna and the vehicle at a distance of thirty feet. Weather conditions were dry. Measurements were taken at 74 and 151 MHz. The measurements range from 6 db to 24 db above 1 microvolt/meter. All vehicles on the station, including private cars pose noise problems, but special attention towards suppression should be given to (a) the snow-plow (257), (b) cherry picker (254), (c) University of Toronto vehicle.

Suppression of interference from appliances and small motors

Interference from electrical appliances is nearly always due to the appliance containing either a commutator-type (A.C.-D.C., universal) motor, or to electrical contacts which open and close frequently such as a thermostat.

At present, there are no problems of this nature existing at ARO; but appliances such as vacuum cleaners, floor polishers, etc., do exist on the station and could cause problems in the future. It is well to know that proper suppression can be carried out, if it is necessary to operate appliances during observing periods.

Interference from thermostats and other contacts can usually be readily cured by connecting a capacitor directly across the contacts. Care must be taken to use leads as short as possible. A 0.1 microfarad or 0.05 microfarad capacitor is usually best. Chokes and feed-through capacitors are effective in the more difficult cases.

The simplest corrective action, to reduce the noise from small A.C./D.C. motors is to stiffen the brush springs, as this has a pronounced effect on the intensity of the noise generated. As the brushes wear, the spring pressure decreases. Stiffening (stretching) the brush springs will often reduce the noise by as much as 20 decibels (10 times).

There is a distinct limit to the amount of noise reduction which can be obtained by stiffening the brush springs, and the next simplest step to obtain further suppression is to connect a 0.05 microfarad or a 0.1 microfarad capacitor across the power line near the motor. The simplest way of doing this is to obtain a small plug-in suppressor such as an Aerovox type 1N-270. This and many other attachments are C.S.A. approved. This simple type suppressor plugs into a wall outlet, and the appliance plugs into it. Such suppressors which contain simple o-1 μF or larger capacitor across the power line, commonly give a 20-db (10 times) reduction in noise level at standard frequencies. Further suppression may be required at frequencies used at ARO and can be accomplished at very little expense.

Suppression of Interference from Oil Burning Furnaces.

In the majority of cases, interference from oil burners is caused by the high tension spark which ignites the oil burner. The blower motor, in late model burners is an induction motor,

which does not cause interference unless defective. Interference can sometimes be caused by intermittent contact of the BK cable and grounded metal, the vibration from the motor causing such contact to make and break. This is readily cured by securely fastening any loose metal parts together.

The ignition interference, in nearly all cases, can be cured by shortening the high tension leads between the electrodes and the ignition transformer, and inserting in one or both of these leads a resistance type suppressor. These suppressors are quite similar to those used on automobiles, but need to be much larger, due to the heavier currents in oil burners. Continental Carbon Company type O.B.15 suppressors are being used and found satisfactory.

If interference is still experienced, all burners should be checked for wiring. Any telephone or lighting wires or any ungrounded conductors, if in close proximity to the furnace should be moved. They may be carrying interference.

In most cases suppression methods described above are adequate, but in some isolated cases further suppression may be required. It has been found that inserting a capacitor-suppressor unit in the 110-volt supply line to the ignition transformer is effective. The several types of filters that are sold for fluorescent lights are suitable for this purpose. Care must be taken that current rating on these suppressors is not less than that of the ignition transformer. The cost of suppression of an

oil burner is in the neighborhood of sixteen dollars. May I suggest that the oil burners in building 1A and 1B, where the furnaces are not in an enclosure, be completely suppressed.

Fluorescent Lighting

Fluorescent lights have long been known as a potent cause of interference. Their lamps depend on conduction through ionized gas. On each reversal of the applied A.C. voltage, the tube changes instantly from a good insulator to a good conductor; thus producing a pulse type interference.

At the beginning of operations at A.R.O., fluorescent lights were installed in our staff-house and at the garage. They present no noise problem, except in one particular instance. Noise measurements were taken in this area and the noise level was 3 db/mV at 74 MHz. The level of noise did not change with the fluorescent light on. The one instance mentioned occurred within fifty feet of the garage with the overhead doors open. On the same frequency and using the meter method, there was a maximum noise peak when the fluorescents were turned on. May I suggest that it is of prime importance that all parts of a lighting system be operating properly and any defective parts be replaced. For example, Flickering bulbs should be left off until replacement is made. All bulb contacts should be examined carefully to ensure that the contact is firm and that no arcing takes place.

Incandescent lamps are preferred for observing sites. If for some good reason incandescent lamps are not suitable, as in small confined areas where heat dissipation is a problem, commercial "interference free" fluorescent lamps could be substituted. Good results also can be had using ordinary equipment with the proper suppression measures.

Site No. 1B

Considerable work is required at this particular site. Because of the frequency used, the interference problem is magnified.

When planning an installation such as Site 1B involving several pieces of electronic equipment, positioning of various units should be given careful thought. Sensitive equipment should be installed as far as possible from units which may be a source of interference. All power, control, and other leads to the equipment should not be physically close to any interference-generating equipment or interference-carrying leads because of the inductive coupling which may exist between the leads.

Good grounding between units can be very important in the reduction of interference, in minimizing the effect of interference, once it is present, and in increasing the effect of suppressors such as filters and capacitors. All antennas should be properly grounded with No. 4 gauge medium drawn copper wire and

should terminate at one central point of the main grounding system. For good operation of the site the (i) time pulses, (ii) air conditioner, (iii) oil burner, (iv) light switches, (v) fans, (vi) cameras all require suppression maintenance. This equipment creates maximum interference when operated.

With some of the equipment now out of operation, it would seem like an opportune time to check the building and perform this necessary work, which would improve conditions when the equipment resumes normal operation.

Recommendations

The following recommendations would be helpful in keeping the noise level to a minimum:

1. Close association should be established between designer, installation personnel and maintenance personnel.
2. When new equipment is being purchased, for example, motors, household appliances, etc., maximum suppression should be required.
3. The level of interference the establishment can tolerate should be determined at each site, and the actual interference maintained below this level.
4. More suitable noise measuring equipment should be purchased.
5. Equipment now in operation that is creating interference problems should be tracked down and suppression methods applied.

6. Good grounding methods are essential to avoid ground loop problems.
7. Wherever possible bundling of power and control cables, leading for example to receivers, should be avoided.
8. Where the requirements of a receiver necessitate the use of a motor for any purpose, it is good practice to have the motor on a separate circuit. This eliminates the possibility of conduction currents that may flow between two circuits.

The above recommendations would be helpful in establishing and maintaining a low noise level at the observatory. Interference and problems associated with it are so numerous that a complete listing along with recommendations would be almost impossible. For example, radio equipment, rotating machinery, mechanical switches, electronic devices, telephone and telegraph lines, circuit switches and dials, incandescent lamps, fluorescent lamps, electric welders, ignition systems, industrial and scientific equipment, household appliances, etc. are all possible interference sources.

In conclusion, suppression measures have already begun. Most, if not all of the NRC vehicles have been shielded. Site 1B is in the process of being re-wired. Proper grounding and protection of the antenna will be carried out, when weather permits.

Suppression methods described throughout were derived from information in our library and the co-operation of the Department of Transport, along with good electrical practice and procedure.

A definite policy for the prevention of interference at the observatory should now be established and enforced.

15 April, 1969.

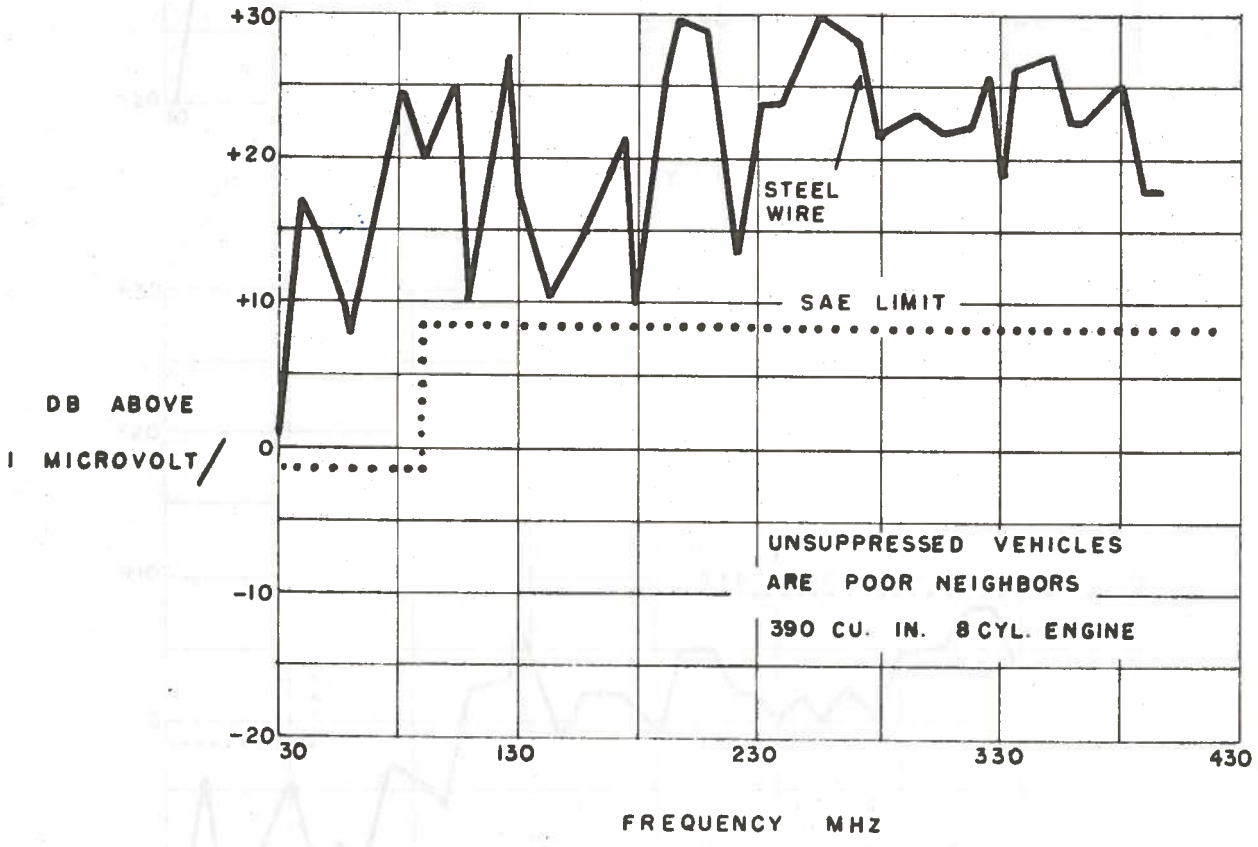
MM/mmh

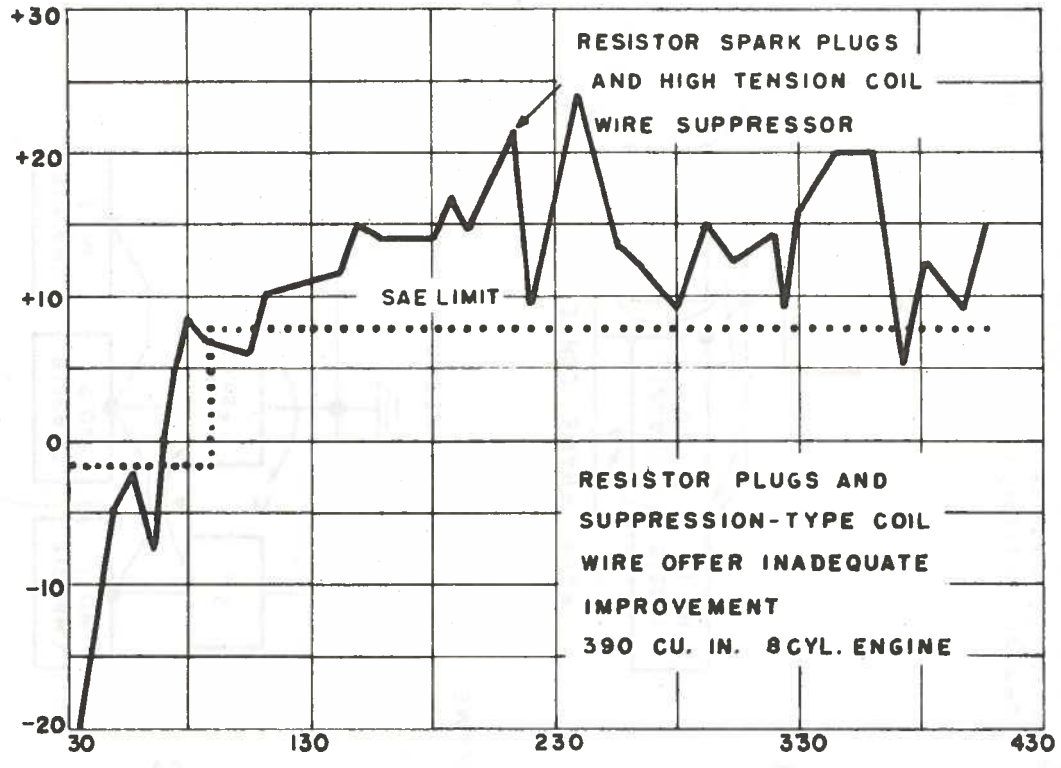
APPENDIX

The following graphs show the radio noise from unsuppressed vehicles as well as from a fully suppressed vehicle.

The circuit for a typical suppression method is also given.

A map showing the results of a survey of radio noise in the area will soon be available.




+30
+20
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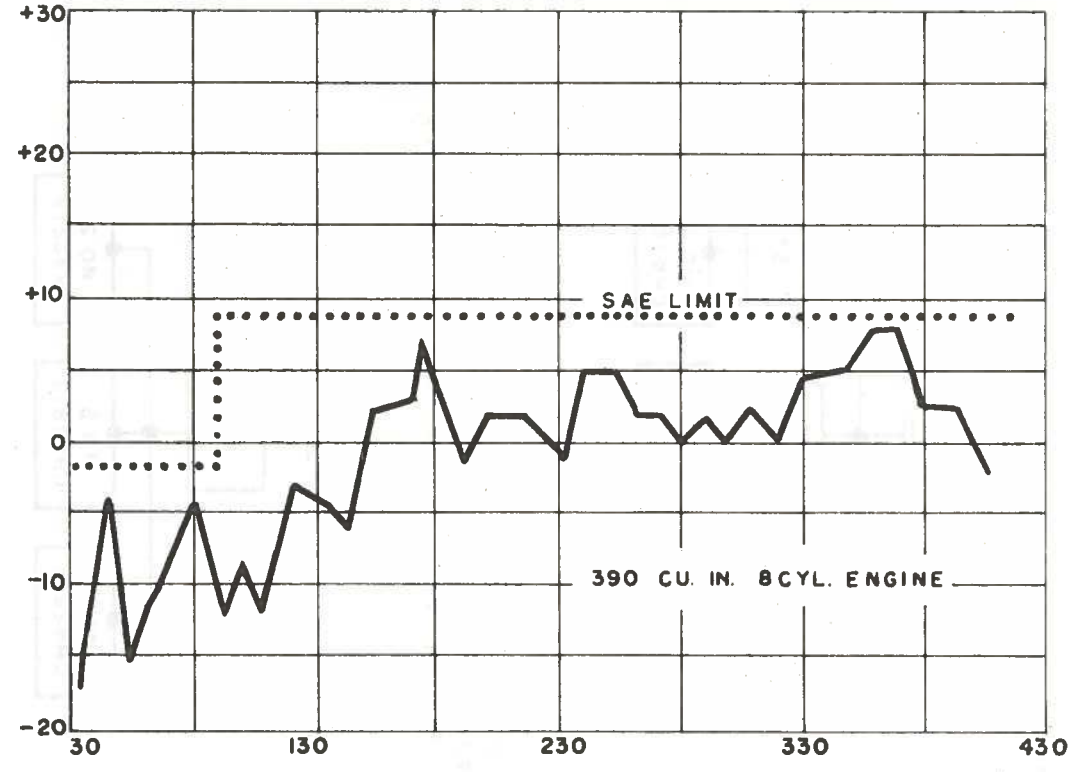
0
-10
-20
30
130
230
330
430
RESISTOR SPARK PLUGS
AND HIGH TENSION COIL
WIRE SUPPRESSOR
SAE LIMIT
RESISTOR PLUGS AND
SUPPRESSION-TYPE COIL
WIRE OFFER INADEQUATE
IMPROVEMENT
390 CU. IN. 8CYL. ENGINE
FREQUENCY MHz


+30
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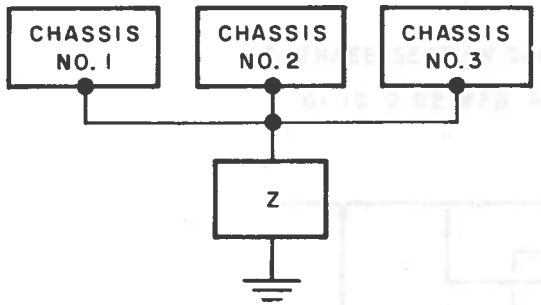
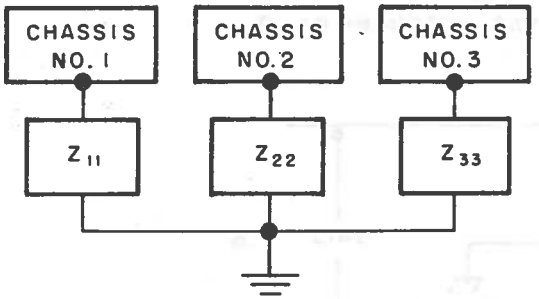
SAE LIMIT
390 CU. IN. 8CYL. ENGINE
FULLY SUPPRESSED VEHICLE

A



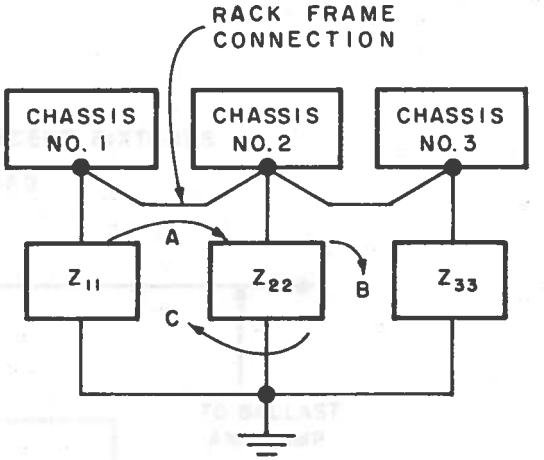
GROUND SYSTEM FOR STRAP-CONNECTED CHASSIS RETURNED TO EXTERNAL GROUND BY A SINGLE LINE.

B



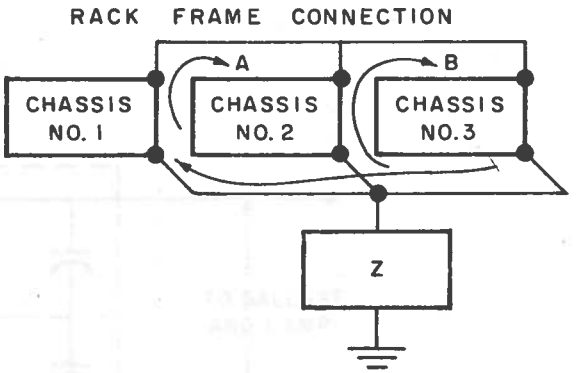
GROUND RETURN CIRCUIT WITH INSULATED CHASSIS AND SEPARATE LINES TO GROUND.

C



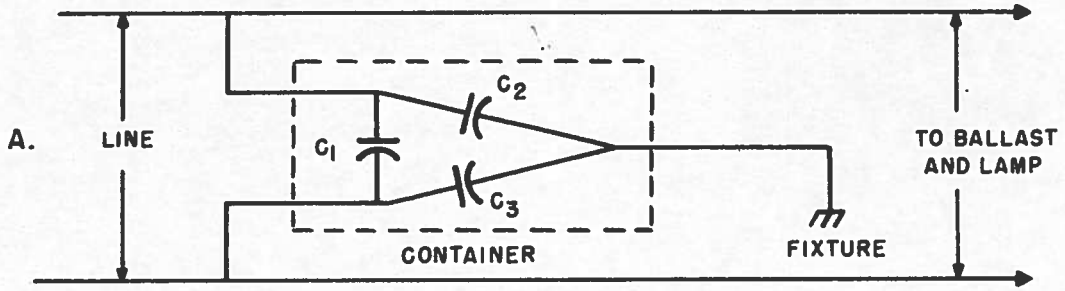
MULTIPLE GROUND RETURN CIRCUIT WITH RACK FRAME CONNECTIONS.

D



GROUND SYSTEM FOR STRAP-CONNECTED CHASSIS RETURNED TO EXTERNAL GROUND BY A SINGLE LINE AND HAVING ADDITIONAL INTERCONNECTIONS THROUGH THE SUPPORTING RACKS.

A. THREE-SECTION CAPACITOR FILTER FOR FLUORESCENT FIXTURES
C1 IS 0.02 MFD AND C2 AND C3 ARE 0.002 MFD



B. AN INDUCTOR-CAPACITOR FILTER