

# Image Cover Sheet

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510352



**TITLE**

MICROBIOLOGICAL CONTAMINATION OF SHIPBOARD FUEL SYSTEMS,  
CAUSES-CONSEQUENCES-CONTROL

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Microbiological Contamination of Shipboard Fuel Systems,  
Causes-Consequences-Control

by

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ABSTRACT

Microbiological contamination (MBC) of fuel tanks and fuel piping by fungi, yeast and bacteria is a common, but often ignored, cause of fuel system failure. The consequences of MBC range from blocked fuel purifiers, coalescers and filters to catastrophic engine failure resulting in repair costs in the millions of dollars. One such case involved fuel contamination which severely damaged several gas turbine engines with resulting repair expenses exceeding seven million dollars. Laboratory analysis of fuel taken from the contaminated tanks confirmed the presence of salt water, suspended particulate and interfacial fungal mats with the predominant organism being *Hormoconis resinae*. The TRUMP updated 280 Class destroyers have water ballasted fuel tanks and therefore possess the potential for MBC related fuel problems. In this presentation, the causes and consequences of microbiological contamination (MBC) in shipboard fuel systems will be discussed as well as DREA research efforts for the control and elimination of MBC.

MICROBIOLOGICAL CONTAMINATION OF SHIPBOARD FUEL SYSTEMS  
CAUSES -CONSEQUENCES - CONTROL

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Microbiological contamination in hydrocarbon fuels presents a variety of problems to the operators of Naval vessels. The causative organisms are fungi, yeast and bacteria. Free water must be present in a fuel tank for these organisms to grow and proliferate. When water is present conditions are favourable for fungal spores (dormant phase) to become viable. The fungi and yeast grow at the fuel/water interface by extracting oxygen from the water molecules and nutrients from the fuel and water layers. The organisms reproduce by cell division creating branching chains (hyphae) which form an interlocking mat at the fuel/water interface. It is this mat which coats fuel tank walls, plugs filters, poisons coalescers and fouls injectors in diesel engines and causes coking of fuel control nozzles and hot spotting in gas turbine engines. Hot spotting in a gas turbine usually results in catastrophic failure requiring engine replacement.

At present the only effective ways to control MBC is by practicing good fuel husbandry and biocide use. The regular stripping of water bottoms from fuel tanks will help minimize microbiological contamination as organisms can grow only if water is present. Biocidal agents are an effective means for the control and/or elimination of microbiological contamination but, due to the toxicity of the active ingredients and environmental concerns, are used only as a last resort and under strictly controlled conditions.

SLIDE 1 - Micrograph of *H. resinea* showing branching chains (hyphae) forming an interlocking fungal mat.

SLIDE 2 - Cross section of a contaminated fuel tank showing:

- (a) clear upper layer of fuel
- (b) middle layer with moisture haze
- (c) microbial mat at the fuel water interface
- (d) water layer with emulsified oil
- (e) microbial slime coating tank bottom

SLIDE 3 - Water and Sediment Test showing water fungal mat at fuel/water interface and water layer with MBC.

SLIDES 4, 5 and 6 - Photographs of fuel tanks contaminated with microbial growth. Note the clean area on the tank bottom in Slide 5. This is due to vacuuming of the tank bottom by the fuel suction pipe. As fuel is drawn from the tank the microbiological contamination is spread through the fuel system.

SLIDE 7 - Coalescer Filter/Water Separator System contaminated with MBC.

SLIDE 8 - Coalescer/filter elements contaminated and blocked with MBC.

SLIDE 9 - Water separator cartridge which has been poisoned by a MBC produced surfactant.

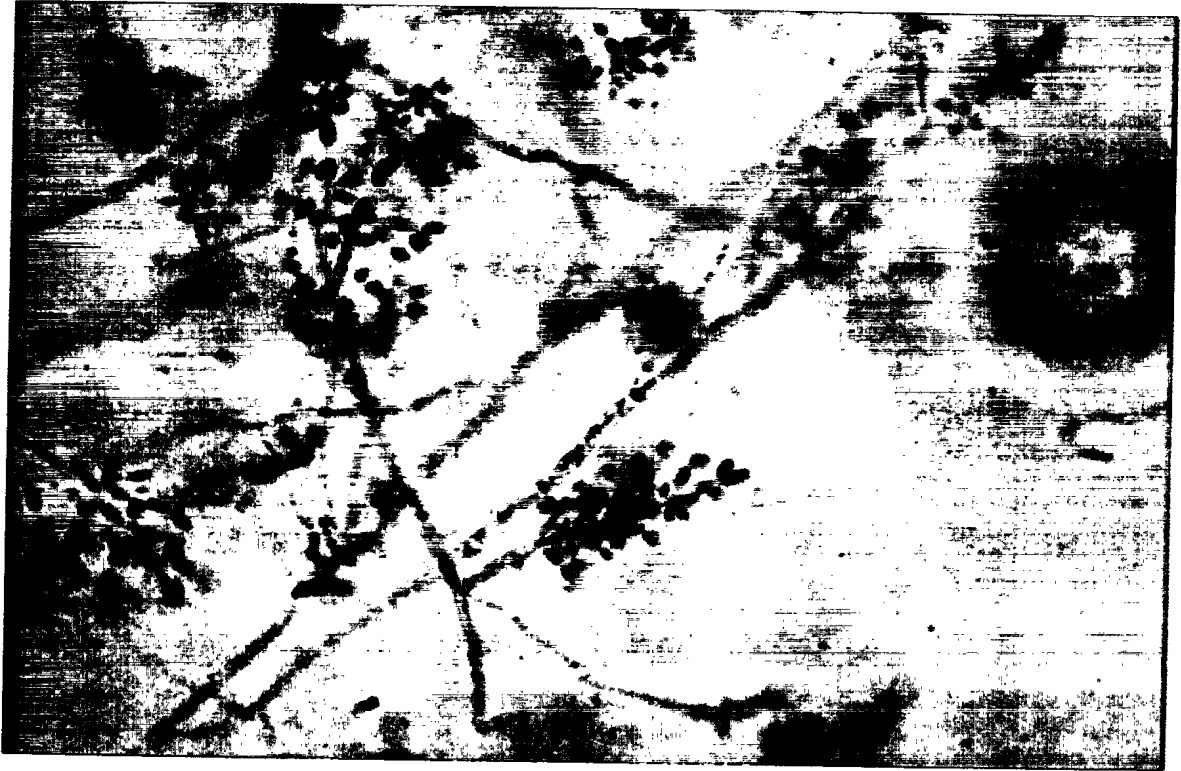
SLIDE 10 - Fuel control nozzle from a gas turbine engine showing severe coking from MBC in the fuel supply. Coking alters the fuel spray pattern and causes hot spotting in the combustion chamber.

SLIDES 11, 12 and 13 - Gas turbine combustion chamber, injector ring and guide vanes showing the effects of hot spotting from burning contaminated fuel.

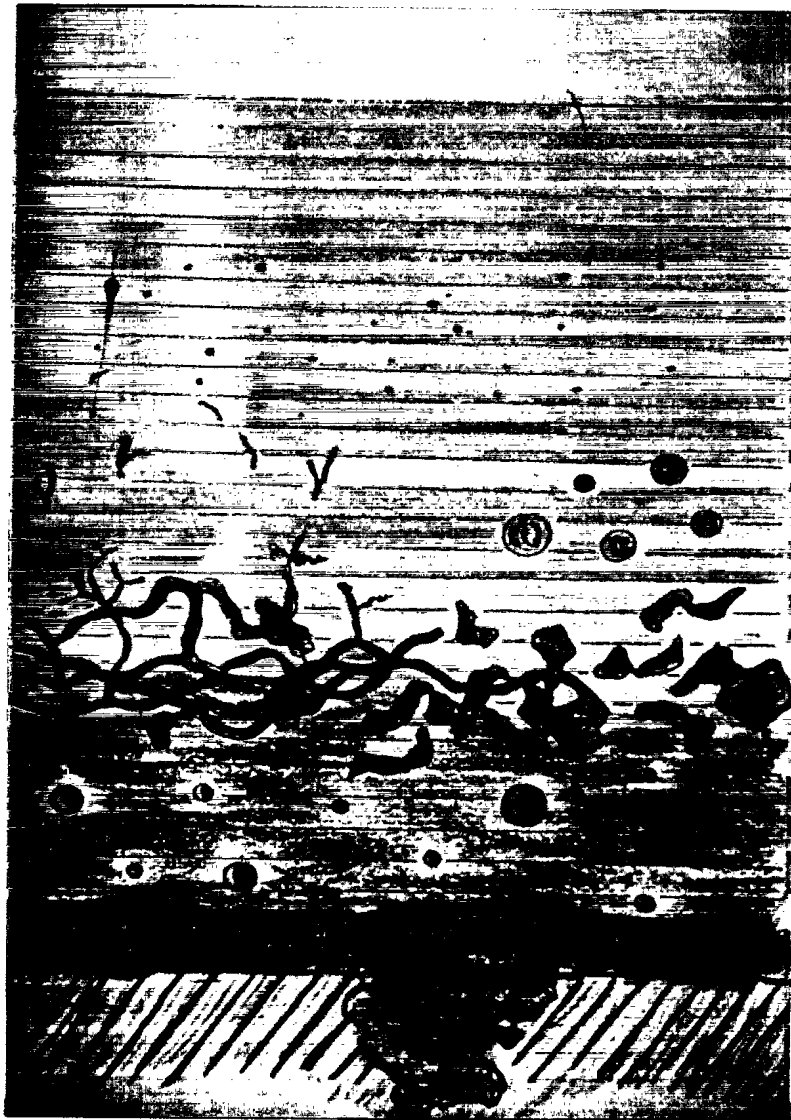
Defence Research Establishment Atlantic is currently conducting research into the application of ultrasonic energy for the destruction of microorganisms in shipboard fuel systems. It is envisioned that the system will consist of a flow through ultrasonic chamber with a capacity of up to 6,000 liters per hour. During FY 93/94 Aastra Aerospace, under

contract to DREA, carried out a literature review and proof of concept for the use of ultrasonic energy for the destruction of microorganisms. The proof of concept included the construction and testing of laboratory scale prototypes of proposed systems. The next phase of this project, which is sponsored by National Defence Headquarters and will be carried out over a three year period, will be the design, construction and testing of a full scale system

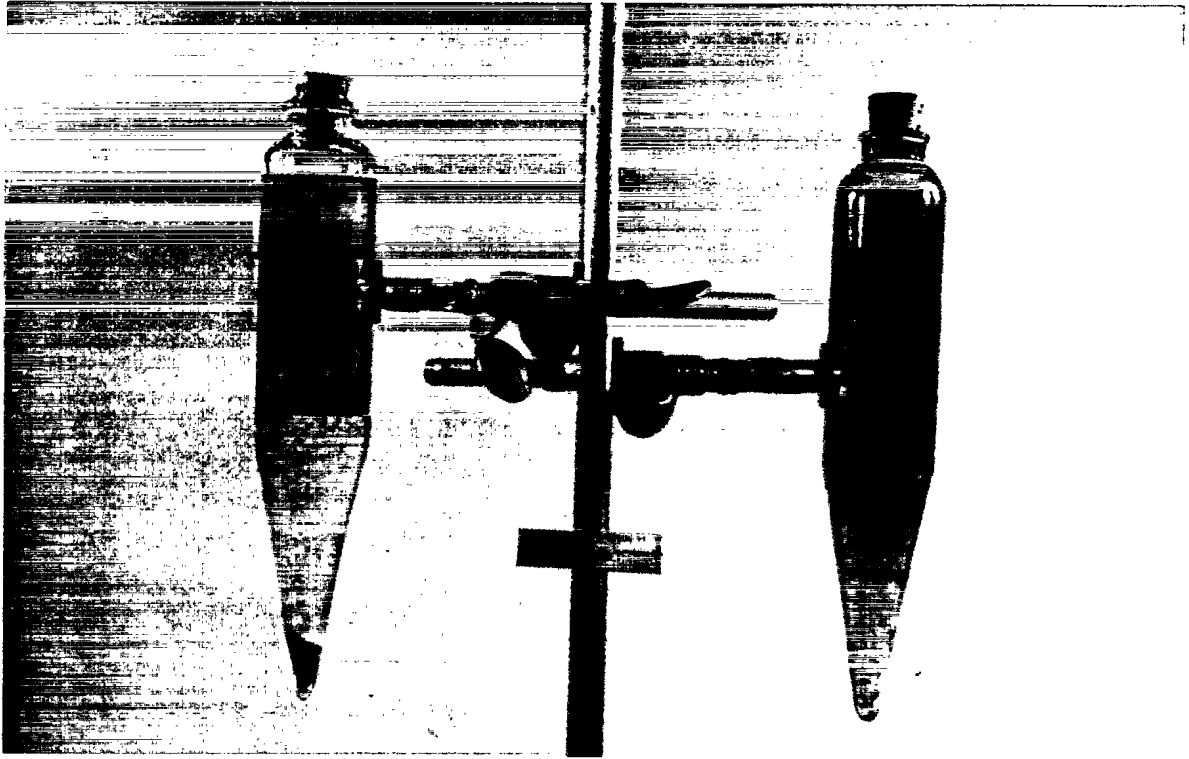
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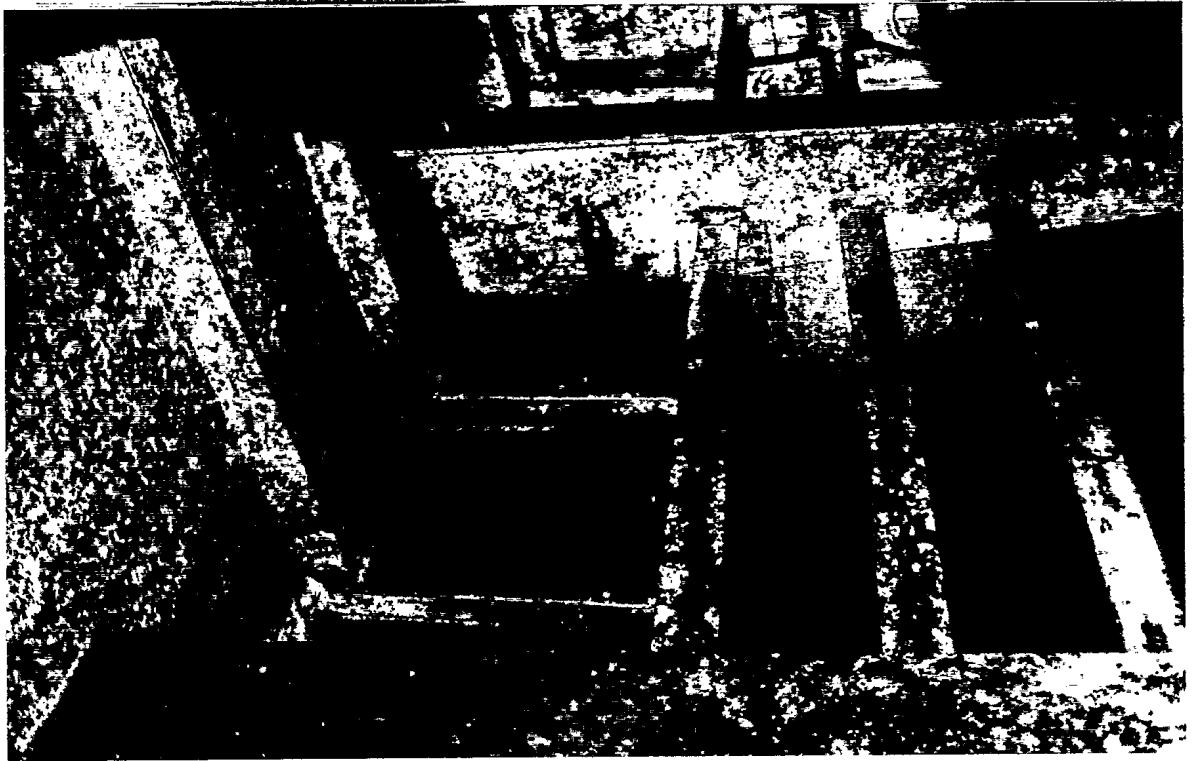


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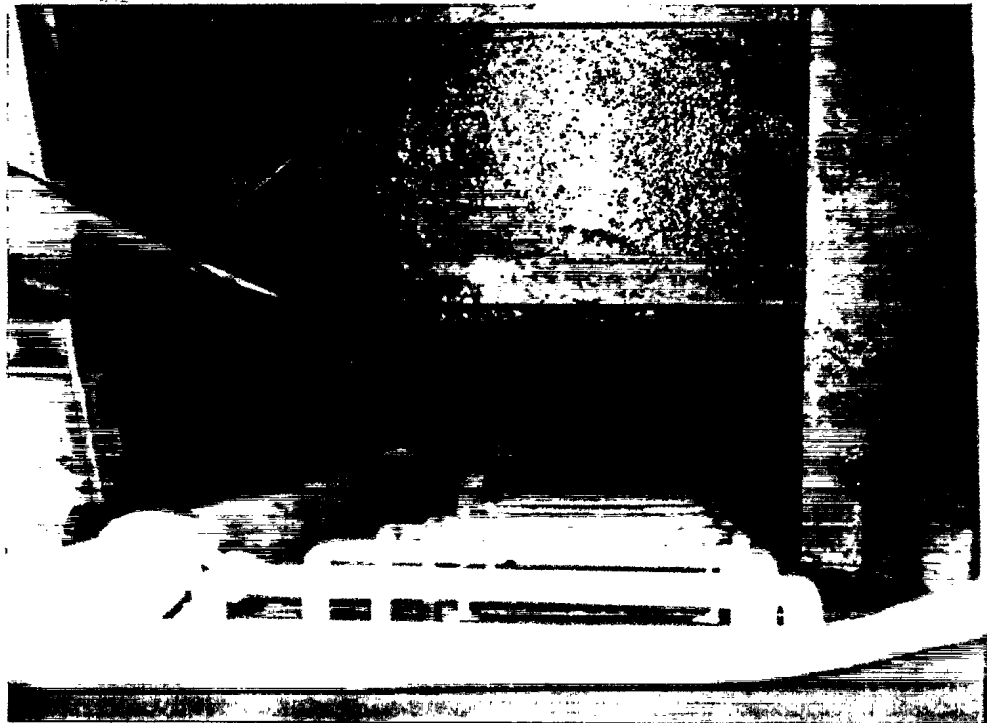




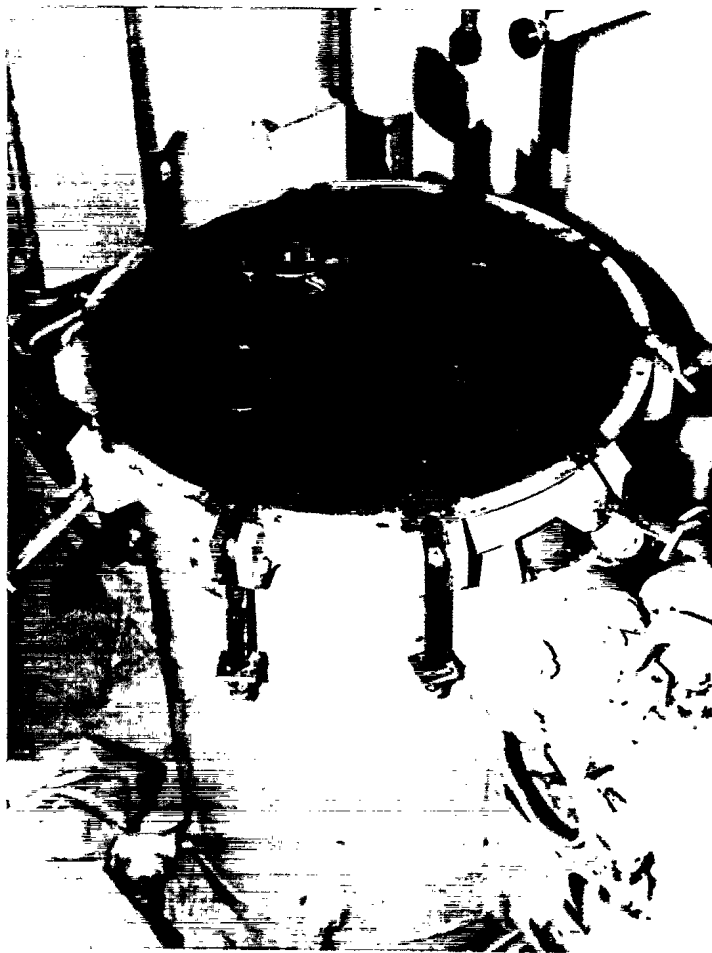
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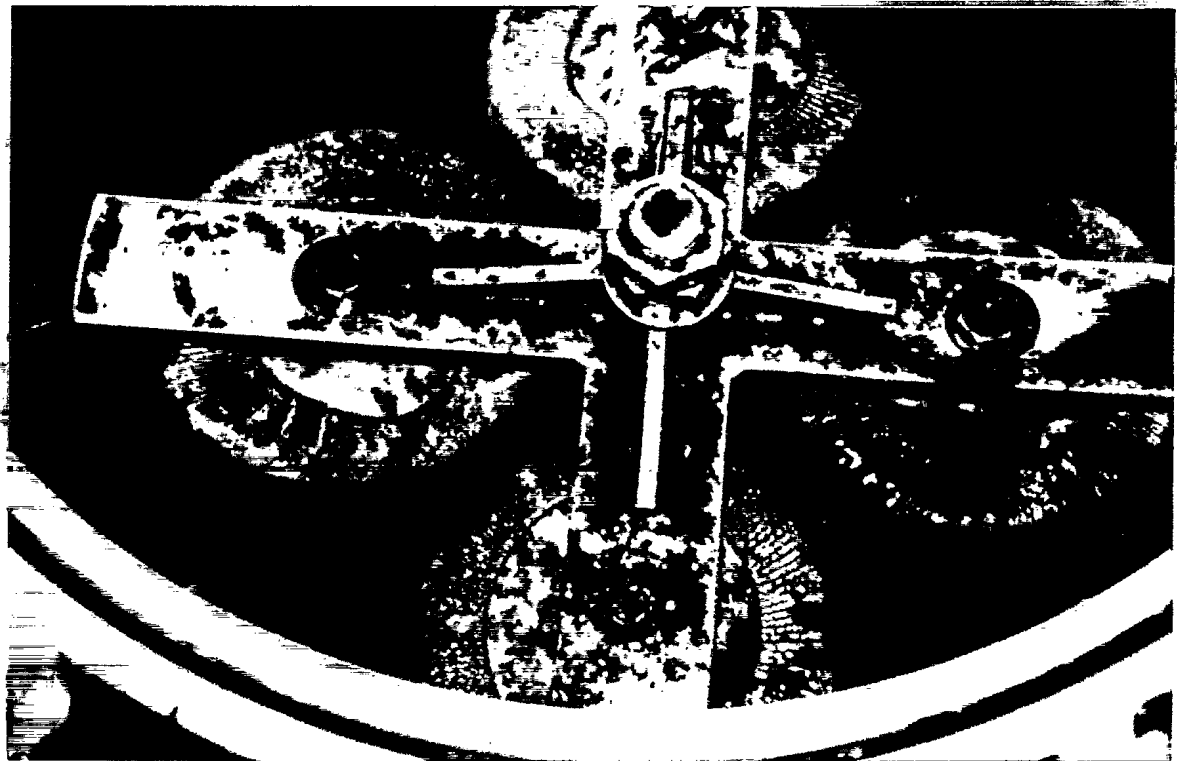
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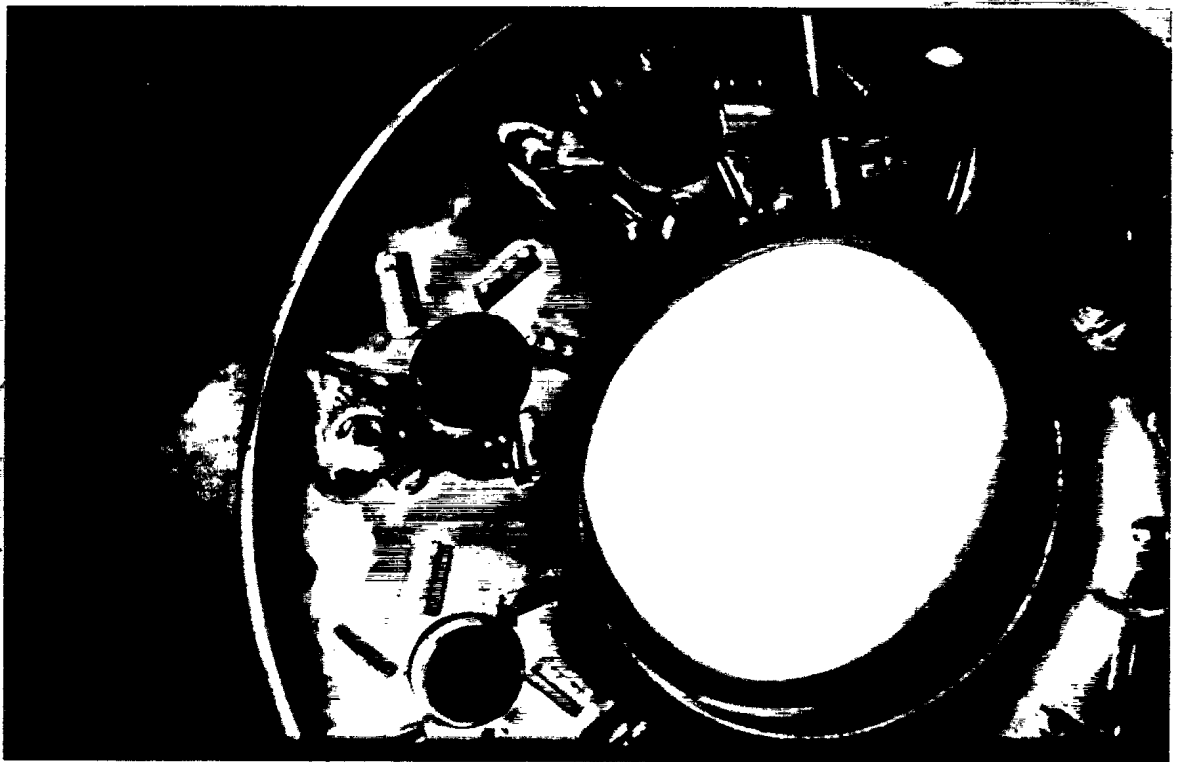
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