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Evaluation of Magnetic Fuel Treatment for Aircraft Fuel Systems

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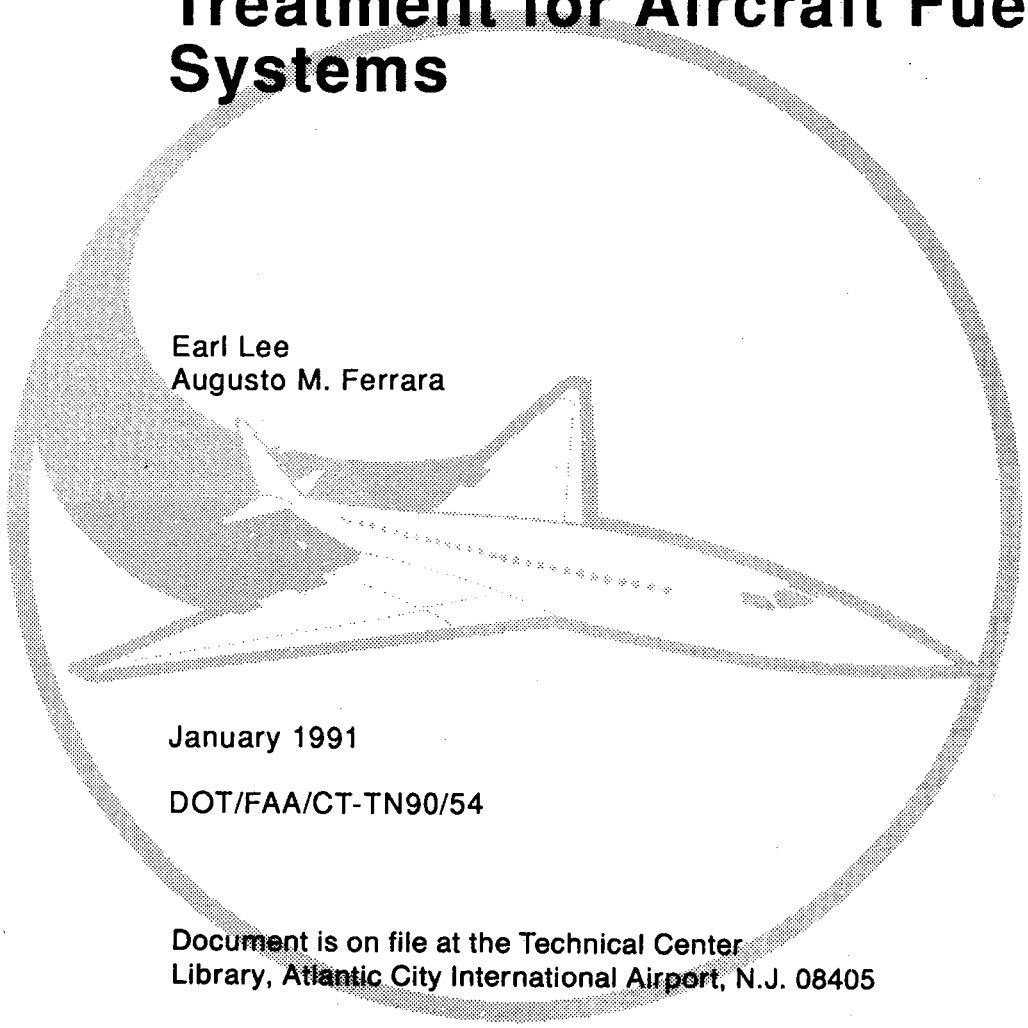

January 1991

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Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
DOT/FAA/CT-TN90/54		

4. Title and Subtitle	5. Report Date
EVALUATION OF MAGNETIC FUEL TREATMENT FOR AIRCRAFT FUEL SYSTEMS	January 1991
	6. Performing Organization Code
7. Author(s) Earl Lee and Augusto M. Ferrara	8. Performing Organization Report No. DOT/FAA/CT-TN90/54
9. Performing Organization Name and Address Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	10. Work Unit No. (TRAIS)
	11. Contract or Grant No.
12. Sponsoring Agency Name and Address U.S. Department of Transportation Federal Aviation Administration Technical Center Atlantic City International Airport, NJ 08405	13. Type of Report and Period Covered Technical Note
	14. Sponsoring Agency Code ACD-210

15. Supplementary Notes

16. Abstract

The Federal Aviation Administration Technical Center evaluated a device which is intended to improve the fuel efficiency of both piston and turbine engines. This device is marketed by Magnetizer Group Incorporated. The theory behind the device calls for passing the fuel through a magnetic field, which alters the fuel's behavior.

The device was evaluated on a Teledyne Continental O-200. There were no significant changes in either the fuel consumption or the power developed when the device was installed.

17. Key Words	18. Distribution Statement
Magnets, Fuel Treatment, Aviation, Efficiency, Power, Fuel Consumption	Document is on file at the Technical Center Library, Atlantic City International Airport, New Jersy 08405

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	26	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

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LIST OF ABBREVIATIONS AND SYMBOLS

Autogas	Automobile Gasoline
ACM	Auxiliary Control Module
BSFC	Corrected Brake Specific Fuel Consumption
cm	Centimeter
DCM	Dynamometer Control Module
DDM	Dynamometer Display Module
EGT	Exhaust Gas Temperature
EPA	United States Environmental Protection Agency
FAA	Federal Aviation Administration
°C	Degree(s) Celsius
kg/hr	Kilogram(s) per Hour
kW	Kilowatt
mmHg	Millimeter(s) Mercury
N·m	Newton Meter(s)
psig	Pound(s) per Square Inch Gauge
psi	Pound(s) per Square Inch
rpm	Revolutions per Minute
TIB	Temperature Indicator Box
VAC	Volts Alternating Current
VDC	Volts Direct Current

EXECUTIVE SUMMARY

The Federal Aviation Administration Technical Center was approached by Magnetizer Group Incorporated following the Avionca accident on January 25, 1990. The Magnetizer Group stated they manufacture a product which improves the efficiency of engines and furnace systems. They felt the use of their product may have given the Avionca Boeing 707 additional range which would have prevented the accident. The Magnetizer Group requested that the Technical Center test one of their devices on a turbine engine to demonstrate its effectiveness. The Technical Center agreed to an initial evaluation of the device on a Teledyne Continental Motor's O-200, which was installed on the Center's dynamometer facility.

The device consists of several ceramic magnets which are mounted on metal backplate(s) so that the south pole of the magnets are directed toward the fuel line, upon which they are mounted. The manufacture claims this configuration alters the fuel's properties, which in turn improves the combustion behavior.

The devices were tested in several configurations and the results compared with several baseline tests. Neither the power developed nor fuel consumption showed any significant changes as a result of installing the devices on the test engine.

INTRODUCTION

The Environmental Protection Agency (EPA) has evaluated a number of magnetic devices used for the treatment of hydrocarbon fuels. With the incident of the Avionca crash, the Federal Aviation Administration (FAA) has observed that such a device may have extended the flight time and allowed the flight crew more time to deal with any difficulties. The initial testing was done on a O-200 Teledyne Continental piston engine as found in a Cessna 152. It was decided before the testing began that if improvement in performance was found by magnetically treating the fuel, then more testing would be done using a turbine engine.

Another part of this study consisted of a literature search which reviewed a number of tests that the EPA conducted and claims by private individuals who have already installed the magnetic devices on their motor vehicles.

THEORY OF OPERATION.

The magnetizing device chosen for testing is manufactured by the Magnetizer Group for the treatment of fuel and water (figure 1). This device is made of a ceramic alloy and is claimed by the manufacturer to be permanently magnetized with a power rating up to 11,000 gauss/unit (reference 1). The manufacturer claims that a powerful magnet will physically affect a fluid as follows:

> As a negatively charged molecule, "normal" water behavior is exhibited. Following exposure to a south pole magnetic field, the electron orbits of the molecule are altered such that the net charge becomes positive.
>
> Because the net charges of the hydrocarbon and oxygen molecules are both negative, there are repulsive forces not attractive forces present.
>
> When magnetized, the fuel's hydrocarbons are ionized to exhibit a net positive charge. The change in charge allows the fuel to aggressively attract and bond with available (negatively charged) oxygen. This creates a more comprehensive hydrocarbon molecule with its own oxygen supply. The end result is a more efficient and fully burning, explosive mixture which now has its own oxygen base (reference 1).

This magnetic device was designed with two or more magnets so that the south poles of each magnet were directed inward toward the fuel and the north poles were directed outward with a steel retaining plate connecting them. Older magnet designs were constructed so that the fuel first encountered the north pole and as it eventually passed the length of the magnet it would pass the south pole. This method is referred to as the "bi-polar method" by the Magnetizer Group (reference 1). This manufacturer has chosen not to use this method because of its limited power as expressed below:

> The shortcoming in all bi-polar applications is that they are inherently low in (power) applied magnetic field strength. The reason is that the field generated by any magnet originates and is concentrated at its head. That field then emanates and disseminates like an umbrella all around the magnet until it goes into the other head; greatly reducing the power at its sides. The field measured at the magnet's sides represents only a very minor percentage of its total magnetic strength (reference 1).

By directing only the south pole into the fluids mass and the north pole away from the fluid, the more powerful field strength found at the head of a magnet is focused into the fluid. This method is known as the "mono-pole method."

TEST APPARATUS

Testing was done at the FAA Technical Center at Atlantic City International Airport, NJ. The Technical Center's Dynamometer Test Facility was used to conduct engine performance tests, and a data acquisition system was used to record all of the parameters listed in table 1.

Magnetizer magnets were chosen for the tests. The magnets were made of a ceramic alloy which the manufacturer claims has a permanent power rating of 11,000 gauss/unit. Each magnet had a length of approximately 8 centimeters (cm), width of 2.9 cm, and thickness of 2.9 cm. The small magnetic device consisted of two of these magnets. The large magnetic device had 3 magnets (figure 1).

The Technical Center's dynamometer is an eddy current design with an absorption capacity of 373 kilowatts (kW) (500 horsepower) and maximum speed of 5000 revolutions per minute (rpm). The O-200 was coupled to the dynamometer, and two wing tanks from a Cessna 152 were installed to provide fuel to the engine (figure 2). Fuel lines from both tanks extended down to the dynamometer bed to a Cessna 172 fuel-selecting device which was driven pneumatically (figure 3). This setup allowed approximately 4 feet of each fuel line to be accessible for installation of magnets prior to the selector valve. During a run, the two conditions could then be selected at any time. The test facility could then run for 5 minutes without magnets, make the switch, then run for 5 minutes with magnets without disturbing the operation of the engine.

TABLE 1. TEST PARAMETERS

Parameter	Units
Ambient Pressure	mmHg
Carburetor Air Temperature	°C
Exhaust Gas Temperature	°C
Fuel Flow	kg/hr
Fuel Line Temperature	°C
Manifold Pressure	mmHg
Power Output Shaft Speed	rpm
Tank in Use Indicator	dimensionless
Torque	N·m

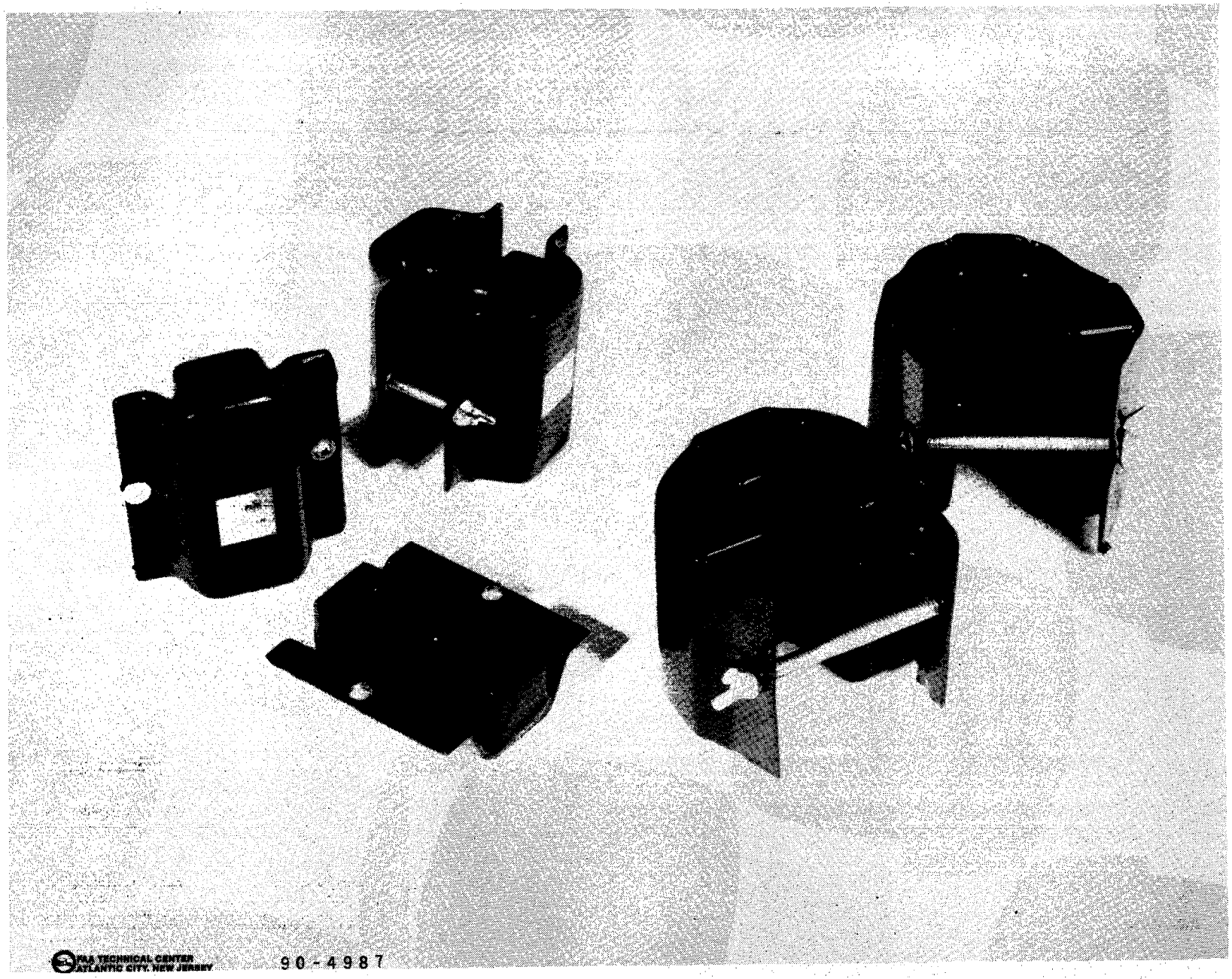

FIGURE 1. MAGNETIZER GROUP MAGNETS

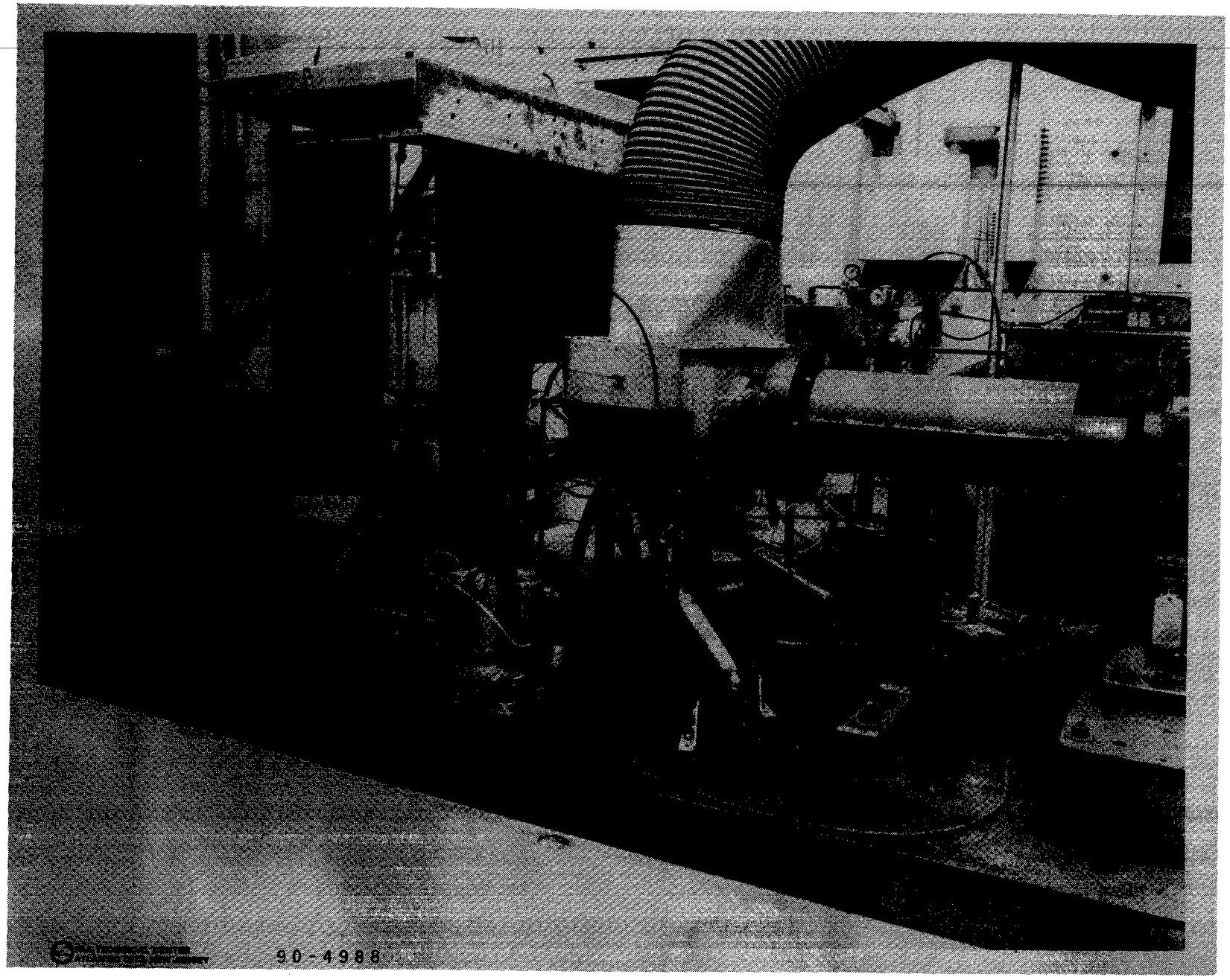

FIGURE 2. DYNAMOMETER WITH THE TELEDYNE CONTINENTAL 0-200 PISTON ENGINE

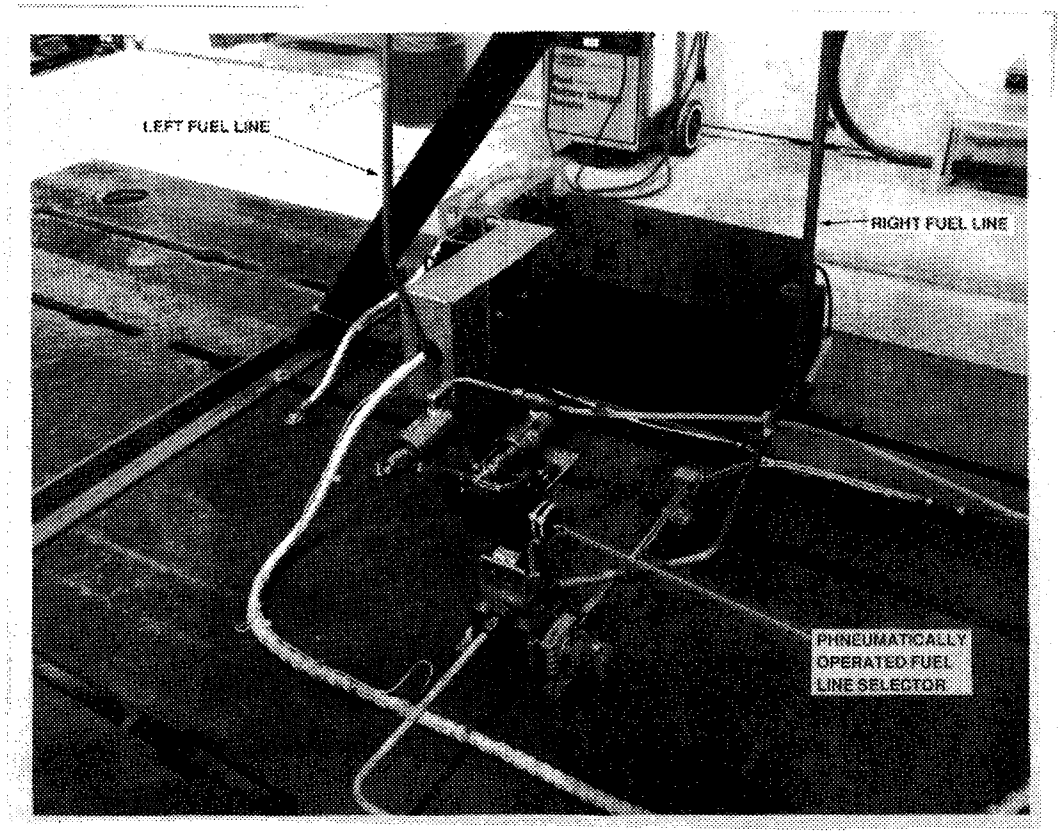

FIGURE 3. FUEL LINE SELECTOR

For the initial tests, a flexible hose connected the fuel system to the carburetor, and one or two of the large magnets could be placed on the fuel line extending from the carburetor to the fuel flow indicator. With this installation, the magnets were not directly adjacent to the carburetor. To position a magnet as close as possible to the carburetor, it was necessary to install a small section of aluminum tubing extending from the carburetor (figure 4). It was also suggested by the manufacturer that the aluminum tube would improve the magnetic field and thus improve engine performance.

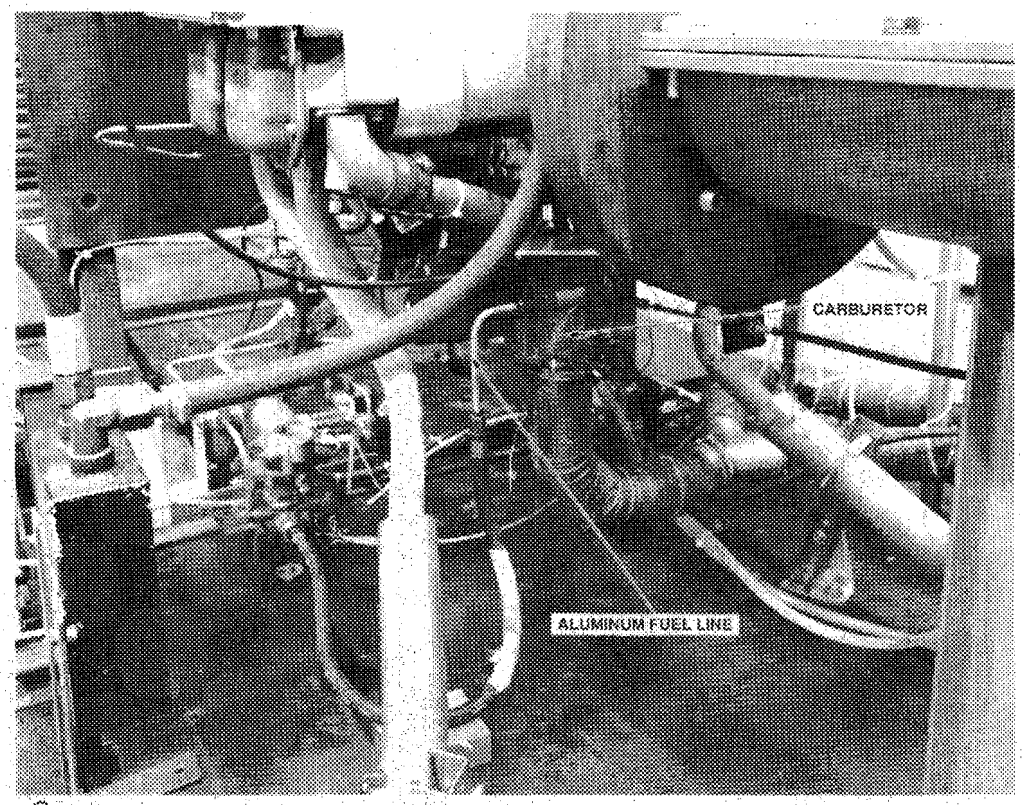

FIGURE 4. ALUMINUM LINE ON CARBURETOR

TEST PROCEDURES

BASELINE TESTS.

The baseline tests were used to established the normal operating parameters and to demonstrate that no differences in performance resulted from switching tanks. The baseline tests were conducted as follows:

1. Fueled the two tanks with automobile fuel (autogas) to similar levels.

2. Followed engine startup checklist (appendix A). After engine was running, allowed oil to rise to operating temperature. Increased power setting to 1800 rpm, recorded data manually, and conducted a magneto check.

3. Increased the power setting to 2000 rpm.

4. Allowed conditions to settle at that point then began recording data.

5. After 5 minutes at the data point, switched tanks. Allowed 1 minute for fuel from previous tank to be consumed then begin recording data.

6. After 5 minutes at point, increased power setting by 100 rpm and repeated steps 4, 5, 6 until 2700 rpm was reached for 5 minutes for both lines.

7. Gradually reduced the power setting and allowed the engine to cool then performed an engine shutdown.

MAGNET TESTS.

All runs with the magnets installed were conducted just as the baseline runs were conducted. The exception was a cruise test which simulated a takeoff and cruise situation for an aircraft. This run was conducted in response to the claims that the effect is cumulative.

The cruise test helped to identify any changes in performance as a result of switching between a tank with magnet(s) to a tank without magnet(s) during a steady state situation. The cruise run was conducted as follows:

1. Fueled the two tanks with automobile fuel (autogas) to similar levels.

2. Followed engine startup checklist. After engine was running, allowed oil to rise to operating temperature. Increased power setting to 1800 rpm, recorded data manually, and conducted a magneto check.

3. Advanced to takeoff power (full throttle) and allowed to stabilize. Began recording data.

4. After 5 minutes, switched tanks and allowed 1 minute for fuel to reach carburetor. Began recording data.

5. After 5 minutes, adjusted power setting to 2300 rpm.

6. Allowed 1 minute to pass and recorded data.

7. After 5 minutes, switched tanks.

8. Repeated steps 6 and 7 for a set duration of time; we chose 1 hour and 30 minutes.

9. Gradually reduced the power setting and allowed the engine to cool and performed an engine shutdown.

TEST SEQUENCE

In order to test the magnets in a number of different configurations, it was decided to do each run with a different magnet setup. The test plan included runs with two small magnets to two small magnets plus two large magnets; a total of four magnets. Four magnets at one time were tested on three of the runs.

The manufacturer claimed that the device worked better after a period of time due to the magnets ability to saturate the metals in its vicinity. For this reason magnets were left on fuel lines for a minimum of 24 hours between runs. All of the magnets (four magnets) were left on the fuel lines for a total of 11 days from run 5 to 6.

The test sequence was as follows:

Run 1 - Baseline

Run 2 - Baseline

Run 3 - Two small magnets were placed on the left aluminum fuel line prior to the fuel selector. The magnets were 6 inches apart (figure 5).

Run 4 - Two small magnets were left on the left fuel line and two large magnets are placed on the flex line between the fuel flow meter and carburetor (figures 5 & 6).

Run 5 - Same magnet configuration as run 4. Cruise run (figures 5 & 6).

Run 6 - Installed aluminum line near carburetor to accommodate one small magnet. Two large magnets on flex line leading to aluminum line and one small magnet on left aluminum fuel line just before the fuel selector (figures 5, 6, 7).

Run 7 - Last baseline.

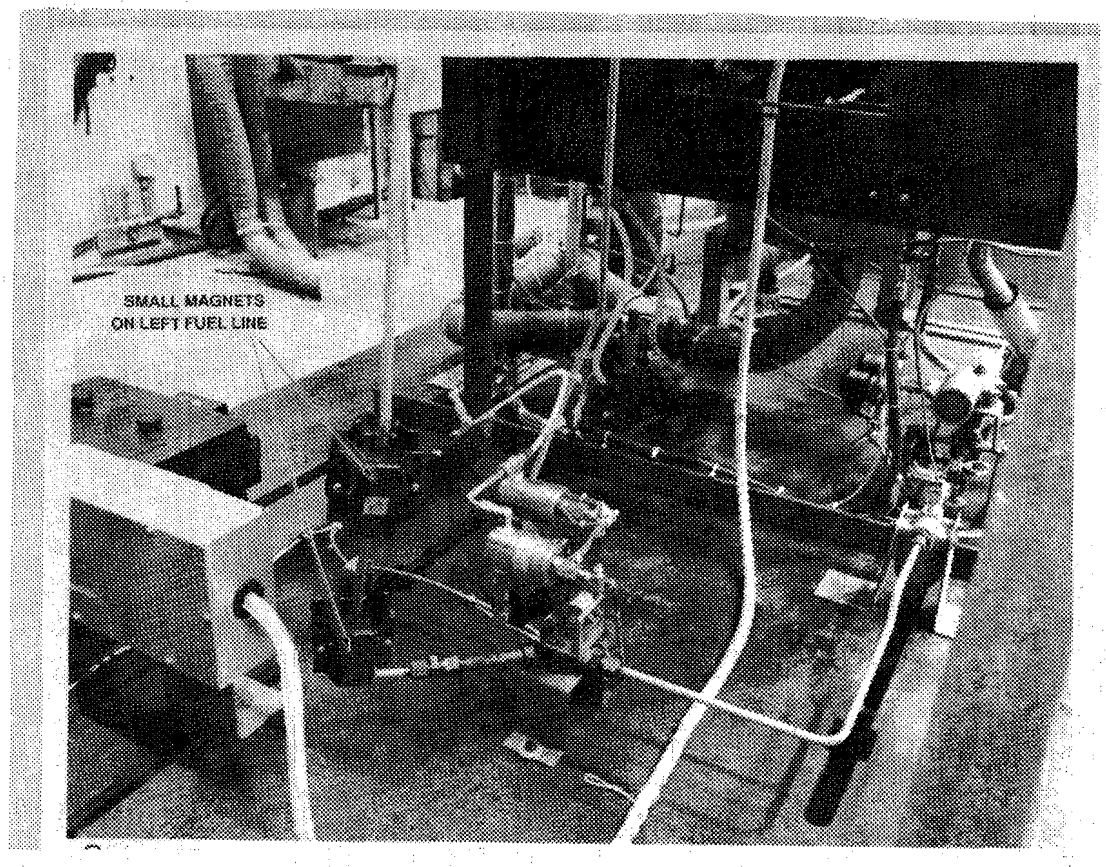

FIGURE 5. SMALL MAGNETS LOCATED ON LEFT FUEL LINE

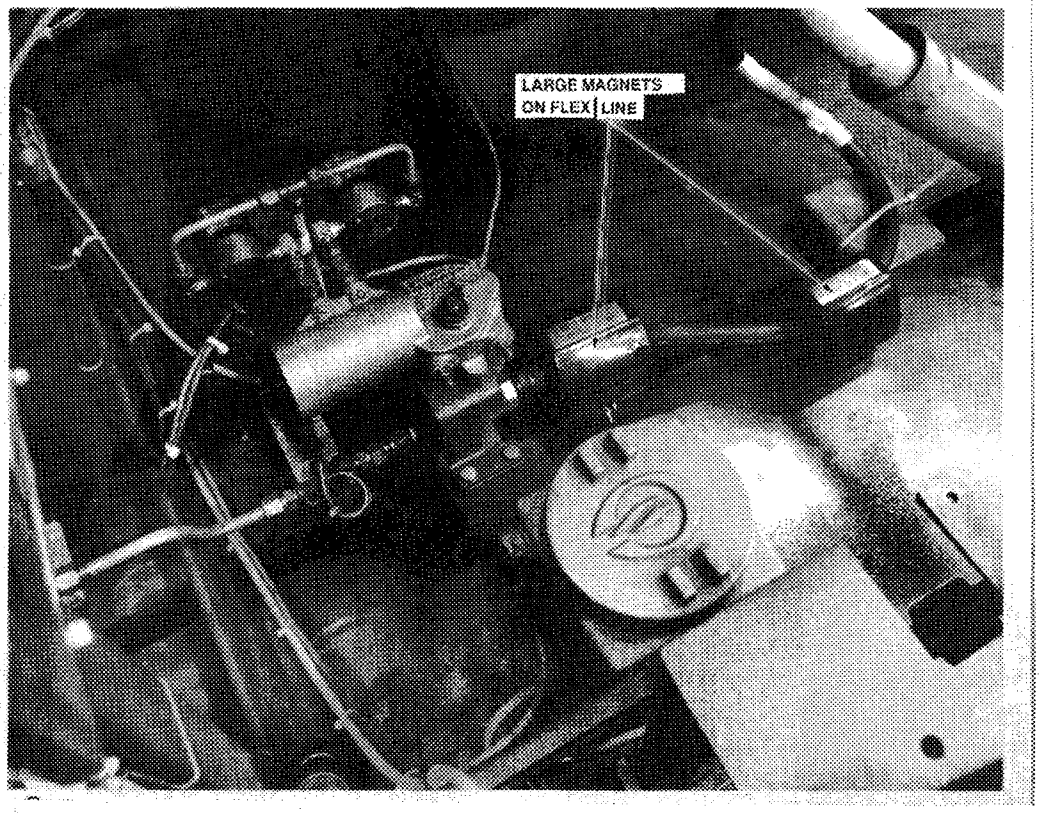

FIGURE 6. LARGE MAGNETS ON FLEX LINE

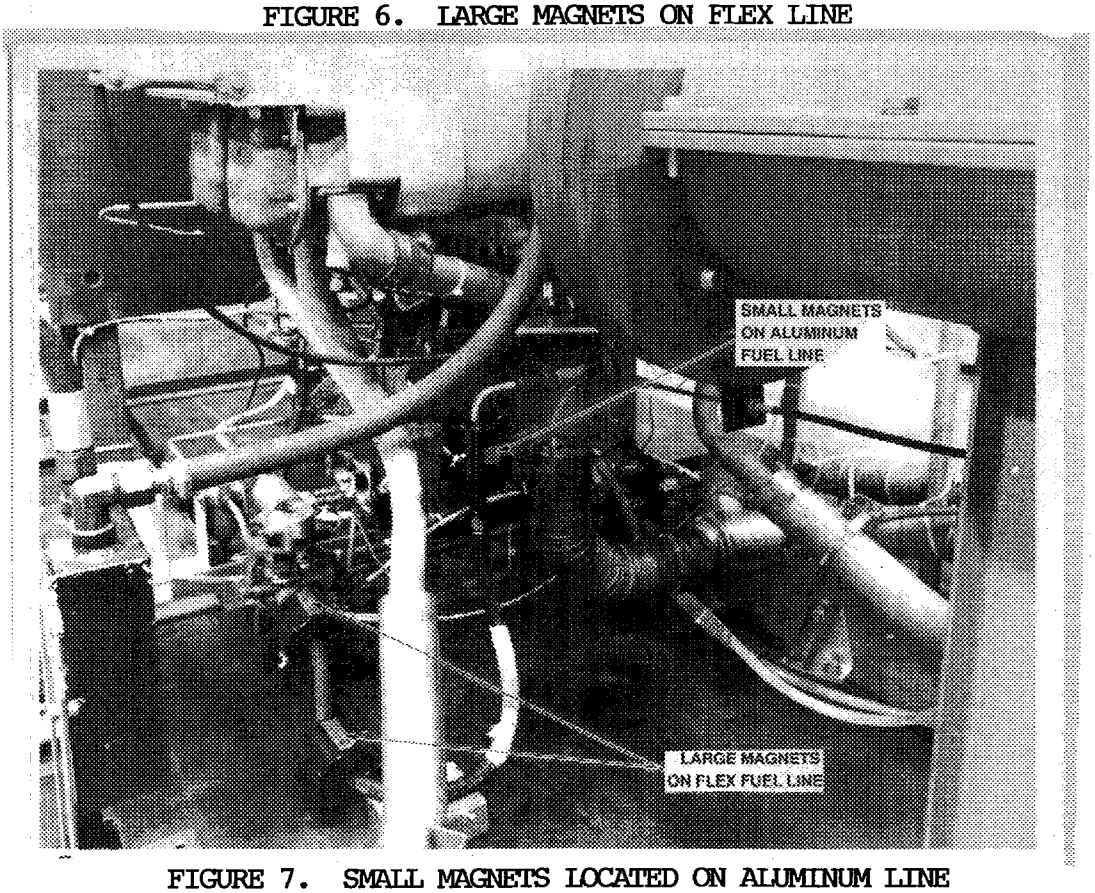

FIGURE 7. SMALL MAGNETS LOCATED ON ALUMINUM LINE

SUMMARY OF RESULTS

LITERATURE SEARCH.

The literature search encompasses most of the technical data published from 1981 to 1985. No technical reports were found from 1986 to the present. Nearly all of the work done in the area of magnetic treatment of fuel and other fluids has been accomplished by the Environmental Protection Agency (EPA). The tests primarily focused on the advantages the device might produce in the automobile industry; however, much of this work can be adapted to general aviation aircraft. There were two devices used primarily in the tests, Super-Mag Fuel Extender and POLARION-X. To give a clearer picture of devices used and theories involved, some of the highlights of the literature search are discussed below.

Both devices operate by nearly the same theory, that is "transforms molecular properties of liquid fuel to maximum combustion" (reference 2). The basic idea is that the magnetic field polarizes the fuel (in this case gives it a positive charge) so that it attracts the negatively charged oxygen molecules. Now the fuel has its own oxygen supply to take with it, creating a more complete burn in the engine (references 2 through 5).

Both of the previous designs used to treat the fuel were to be specifically mounted between the carburetor and the fuel filter about 3 inches from the carburetor. If a rubber fuel hose feeds the carburetor then that hose was to be replaced with a steel or copper tube. Claims by the manufacturers are to the affect that the steel or copper tube absorbs the magnetic fields and increases the total affect on the fuel (references 2 and 3). The POLARION-X is made of "very strong ceramic-type magnets which are not as sensitive to engine heat and maintain their forces" (references 4 and 5). The south poles of the POLARION-X are all directed at the fluids mass, just as the Magnetizer (references 4 and 5). Whereas the Super-Mag Fuel Extender directs the north pole of one magnet and the south pole of another into the fluids mass. In essence, the POLARION-X magnets repeal each other and the Super-Mag magnets attract each other.

The test procedures involved the selection of three vehicles which would represent a wide range of models, manufacturers, and years. Four, six, and eight cylinder vehicles were chosen so that each one was from a different manufacturer. This allowed each engine size and each manufacturer to be represented (reference 2 through 5).

Overall the EPA concluded that the POLARION-X device did not improve emissions, fuel economy, or engine operation of the test vehicles (reference 5). The EPA's evaluation of the Super-Mag Fuel Extender concluded with similar results showing no improvement in fuel economy and no changes in emissions (reference 2).

MAGNET TESTS.

Table 2 summarizes the data in appendix B obtained from the magnet tests and baseline runs. Table 2 is divided into three important parameters. Each parameter gives a measured value for the power setting indicated with reference to the conditions of the run.

The first parameter is Corrected Fuel Flow. The fuel flow is given for each power setting with reference to the run and configuration of magnets if any. The values were mostly sporadic, showing no clear trend towards improvement. After looking over the engine, it was found that the idle adjustment screw was slowly backing out during the runs. This would cause the engine to run richer at idle and leaner at takeoff. This could have been the reason for the steady decline in fuel flow at the 2500 and above rpm setting.

The second parameter evaluated was Corrected Power. No increase in performance was discovered. Of all the runs, baseline run 2 showed the best performance for the majority of the power settings. Run 3 compares two of the small magnets to no magnets at all and shows no significant changes in performance.

Corrected Brake Specific Fuel Consumption (BSFC) showed no clear pattern of improvement throughout the test. Most of the lows and highs of each power setting were found in the baseline data thus leaving magnet tests somewhere in between. For example, the 2400 rpm power setting has a low of 0.256 and a high of 0.273, and all magnet test values are found between this range. The values are again sporadic; however, they do fall within a range of normal test variability.

When data accumulated through run 4 showed no improvement, the manufacturer claimed that a constant power setting for a period of time would show results. A cruise setting of 2300 rpm was chosen as a point most used by general aviation aircraft. This point was operated up to 1 hour and 30 minutes with periodic switches every 5 minutes between two magnets and four magnets. Table 3 is a summary of the data recorded from this run. The table is divided into three important parameters. Each data point is the equivalent to 5 minutes. The average baseline was found from baseline runs 1 and 2.

In all three of the test parameters, the values were intermittent and showed no trend towards improvement. The small variances indicated fall well within the ranges of normal test variability.

CONCLUSION

The devices that were evaluated on the Federal Aviation Administration Technical Center's Dynamometer Test Facility did not affect either the power developed or the fuel consumption. The Technical Center evaluated several different configurations and conditions based on the suggestions of the manufacturer. None of these changes yielded any improvement in overall efficiency.

TABLE 2. SUMMARY OF TEST DATA

CORRECTED FUEL FLOW

RUN	DESCRIPTION	2000	2100	2200	2300	2400	2500	2600	2700
1	Baseline Rt tank	10.5	11.1	12.0	12.6	13.2	15.8	17.3	21.6
	Baseline Lt tank	10.5	11.2	11.9	12.5	13.2	16.1	17.2	21.6
2	Baseline Rt tank	10.8	11.4	12.3	13.0	13.7	15.2	17.2	21.5
	Baseline Lt tank	10.8	11.3	12.1	12.7	13.5	15.1	17.3	21.6
3	No mag	10.7	11.7	12.3	12.8	14.0	14.8	16.5	21.4
	2 sm mag	10.8	11.4	12.1	12.6	13.4	14.5	16.3	21.6
4	2 lg mag	10.7	11.3	11.8	12.4	13.6	14.9	16.3	21.1
	2 lg & 2 sm mag	10.5	11.4	11.7	12.4	13.2	14.6	16.2	21.2
5	2 lg mag				12.5				20.8
	2 lg & 2 sm mag				12.4				21.1
6	2 lg & 1 sm mag	10.7	11.4	12.0	12.5	13.5	14.8	15.8	21.2
	2 lg & 2 sm mag	10.6	11.6	12.1	12.5	13.8	14.9	15.8	21.3
7	Baseline Rt tank	10.6	11.3	11.7	12.0	12.9	14.3	15.2	20.7
	Baseline Lt tank	10.4	11.3	12.7	12.8	13.1	14.7	15.2	20.6

CORRECTED POWER, kW hr

RUN	DESCRIPTION	2000	2100	2200	2300	2400	2500	2600	2700
1	Baseline Rt tank	34.2	37.2	44.0	46.2	51.3	55.6	59.1	65.9
	Baseline Lt tank	33.9	37.5	43.3	46.1	51.5	55.9	58.4	66.1
2	Baseline Rt tank	36.4	38.8	43.5	47.2	51.7	57.0	59.8	63.7
	Baseline Lt tank	36.4	38.4	43.0	47.2	51.3	56.2	60.2	62.9
3	No mag	34.5	38.6	42.9	45.8	50.4	54.2	58.5	64.3
	2 sm mag	35.5	38.0	42.8	45.7	49.7	54.0	57.9	64.8
4	2 lg mag	35.1	37.9	41.6	45.8	49.9	55.4	58.9	64.3
	2 lg & 2 sm mag	34.9	38.0	41.4	45.7	50.0	55.0	58.8	64.7
5	2 lg mag				46.0				62.8
	2 lg & 2 sm mag				46.0				63.6
6	2 lg & 1 sm mag	34.3	39.2	42.8	46.5	50.2	55.0	58.5	65.9
	2 lg & 2 sm mag	34.6	38.5	42.8	46.5	50.6	54.8	58.7	65.8
7	Baseline Rt tank	32.7	36.8	40.4	43.5	48.1	52.7	56.7	62.9
	Baseline Lt tank	32.3	36.7	42.7	43.3	47.9	53.0	56.4	63.2

CORRECTED BSFC

RUN	DESCRIPTION	2000	2100	2200	2300	2400	2500	2600	2700
1	Baseline Rt tank	.306	.299	.274	.272	.256	.285	.292	.329
	Baseline Lt tank	.310	.298	.276	.272	.256	.287	.294	.326
2	Baseline Rt tank	.298	.295	.282	.275	.265	.268	.288	.338
	Baseline Lt tank	.297	.295	.281	.269	.264	.268	.287	.344
3	No mag	.311	.303	.286	.280	.278	.272	.282	.333
	2 sm mag	.306	.299	.283	.275	.270	.268	.282	.332
4	2 lg mag	.305	.298	.282	.270	.273	.269	.277	.328
	2 lg & 2 sm mag	.302	.299	.283	.271	.264	.265	.275	.328
5	2 lg mag				.271				.331
	2 lg & 2 sm mag				.269				.332
6	2 lg & 1 sm mag	.312	.290	.281	.270	.270	.270	.270	.322
	2 lg & 2 sm mag	.307	.300	.282	.269	.273	.273	.269	.323
7	Baseline Rt tank	.324	.308	.290	.276	.269	.271	.268	.329
	Baseline Lt tank	.320	.309	.297	.295	.273	.278	.270	.327

TABLE 3. CRUISE RUN DATA (RUN 5)

CORRECTED FUEL FLOW, kg/hr

Data Point	2 Large Magnets	Data Point	2 Small & 2 Lg Magnets	Average Baseline 2300 rpm
1	12.48	2	12.39	12.70
3	12.40	4	12.29	12.70
5	12.45	6	12.35	12.70
7	12.44	8	12.39	12.70
9	12.43	10	12.49	12.70
11	12.44	12	12.30	12.70
13	12.42	14	12.33	12.70
15	12.42	16	12.41	12.70
17	12.64	18	12.33	12.70

CORRECTED POWER, kW hr

Data Point	2 Large Magnets	Data Point	2 Small & 2 Lg Magnets	Average Baseline 2300 rpm
1	46.15	2	46.33	46.69
3	45.86	4	45.79	46.69
5	46.31	6	45.98	46.69
7	46.48	8	46.06	46.69
9	45.97	10	46.45	46.69
11	45.62	12	45.80	46.69
13	45.83	14	45.61	46.69
15	46.04	16	45.72	46.69
17	45.71	18	45.96	46.69

CORRECTED BSFC, N/kWhr

Data Point	2 Large Magnets	Data Point	2 Small & 2 Lg Magnets	Average Baseline 2300 rpm
1	0.270	2	0.267	0.272
3	0.270	4	0.268	0.272
5	0.269	6	0.269	0.272
7	0.268	8	0.269	0.272
9	0.270	10	0.269	0.272
11	0.273	12	0.269	0.272
13	0.271	14	0.270	0.272
15	0.270	16	0.271	0.272
17	0.276	18	0.268	0.272

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APPENDIX A

0-200 POWER-UP CHECKLIST

I. ELECTRICAL POWER
   A. 28 VDC
      1. Push and hold 28 VDC rectifier button for 3 seconds.
      2. Assure cab 1, 28 VDC circuit breaker is in.
      3. Turn on cab 1, 28 VDC power switch.
   B. Daytronic
      1. Check power switch on back of daytronic for on position.
      2. Turn on key to power-up daytronic.
   C. AC power
      1. Plug in dyno control station power cord into 117 VAC.
      2. Assure cab 1, 110 VAC circuit breaker is in.
      3. Turn on 110 VAC power switch on cab 1.

II. ENGINE CONTROLS
   A. Cab 1
      1. 0-200 oil cooler switch on.
      2. Set oil cooler temperature controller to 175.
   B. ACM
      1. Assure magneto switch is on both.
      2. Set fuel selector switch to left tank.
      3. Place mixture pot selector in position "A".
      4. Set "A" pot to 0, "B" to 1000.
      5. Assure induction air switch off.
   C. DCM
      1. Record hour meter time in engine log book.
      2. Engine fuel and ignition switches off.
      3. Assure emergency stop button is out.
      4. Check for all fault lights on (if DCM had power off).
      5. Assure command selector switch on manual.
      6. Assure control selector switch on load.
      7. Set both speed/load pots to zero.
      8. Set throttle pots, "A" to 100 and "B" to 1000.
      9. Condition switch to "A".
   D. DDM
      1. Put temperature selector on 1 (EGT).
      2. Assure fuel rate, speed switch is on speed.
      3. Put the three temperature controller red needles on maximum.
      4. Push in the three temperature controller knobs.
   E. COOLING AIR PANEL
      1. Push system start switch.

III. TEST CELL
   A. Water System
      1. Open oil cooler water valve.
      2. Open dyno cooling water valve.
      3. Visually check the water connections for leaks.
   B. Starting System
      1. Check batteries for water and terminals for tightness and corrosion.
      2. Visually check the starter leads.

C. Air System
   1. Turn on air supply valve.
   2. Assure there is 90 PSI minimum on supply gage.
   3. Set system pressure regulator to 25 PSI.
   4. Set throttle actuator, pressure regulator to 15 PSI.
   5. Set mixture control actuator, pressure regulator to 15 PSI.

D. Dynamometer
   1. Pull red button on the start fuel module.
   2. Assure the small red light on the relay box is illuminated.
   3. plug in the 117 VAC power cord for the transformer box.
   4. Assure the small red light on the transformer box is illuminated.
   5. Assure air conditioners are plugged in and on high fan.
   6. Assure the hand brake wheel is fully counter clockwise, and "u" is visible.
   7. Assure oilers are more than 1/2 full.
   8. Check flywheel and drive shaft attach bolts for tightness.

E. Engine
   1. Assure mixture control lever is on "L" stop.
   2. Empty oil breather separator.
   3. Check the engine oil level. Add if it is 4 1/2 quarts or lower.
   4. Assure fuel safety valve is shut, drain water from fuel strainer.
   5. Assure transducer box heat and power supply power cords are plugged into 117 VAC, and temperature controller is set to 100.
   6. Check engine for general condition, including mag relays fully inserted and fuel tank selectors on the left tank.
   7. Assure proper amount and type fuel in tanks.

IV. CONTROL TEST

A. Mixture and Throttle
   1. Assure mixture control lever goes to "R", stop when condition switch is set to B.
   2. Set mixture condition switch back to A.
   3. Assure throttle goes to full power stop when switch is set to B.
   4. Set switch back to A. Set B throttle pot to 100.

B. Safety
   1. Turn on rotating beacon.
   2. Blow horn three times before engine start.

0-200 ENGINE START CHECKLIST

1. Assure 0-200 Power-up Checklist was recently completed.

2. Push button 1 on the temperature indicator and turn the rotary selector to number 2 on the TIB.

3. The fault mode lights should be:
   1 = on or off
   2 = on
   3 = on
   4 = off
   5 = off
   6 = off
   Master = on

4. Assure oil cooler temperature controller red light (water off) is on.

5. Sound klaxon three times if not recently accomplished.

6. If engine is cold, set the DCM condition "B" throttle pot to 1000. Move the DCM condition switch several times from "A" to "B", pausing for several seconds each move. Return "B" throttle pot back to 100.

7. Hold fault mode reset switch (master light should go out).

8. Turn on induction air, fuel, and ignition switches.

9. Hold starter button. After engine rotates, move ACM mixture condition switch to "B".

10. When engine is running, release starter button and very quickly check oil pressure. (If there is no pressure indication within 30 seconds, move ACM mixture condition switch to "A" and release fault mode reset switch.)

11. When there is a normal oil pressure indication (30 to 60 psig), release fault mode reset switch.

APPENDIX B

BASELINE AND MAGNET TEST RUNS

Column 1 - Test number and Run number

Column 2 - Average revolutions per minute for appropriate run

Column 3 - Manifold pressure in inches mercury

Column 4 - Tank selection identifier, 0.0 is the right tank and 1.0 the left tank

Column 5 - Carburetor air temperature in degrees celsius

Column 6 - Ambient pressure in inches mercury

Column 7 - Torque in foot pounds

Column 8 - Fuel flow corrected for standard day, expressed in kilogram(s) per hour

Column 9 - Brake Specific Fuel Consumption corrected for standard day, expressed in kilogram(s) per kilowatt hour

Column 10 - Engine power corrected for standard day, expressed in kilowatt hour

APPENDIX B

BASE LINE RUNS

TEST -RUN	RPM	MAP inHg	TANK 0.0 Rt 1.0 Lt	CARB AIR deg C	AMBIENT inHg	TORQUE ft-lb	FUEL FLOW CORR'D	BSFC CORR'D kg/KW hr	POWER CORR'D kW hr
T1-R1	2000.8	22.69	0	31.54	30.31	114.96	10.5	0.306	34.2
T1-R1	2091.6	23.23	0	28.72	30.31	120.72	11.1	0.299	37.2
T1-R1	2257.9	24.90	0	33.21	30.31	130.00	12.0	0.274	44.0
T1-R1	2300.7	25.40	0	34.08	30.32	133.79	12.6	0.272	46.2
T1-R1	2416.7	26.50	0	32.47	30.32	142.18	13.2	0.256	51.3
T1-R1	2524.1	27.16	0	34.17	30.31	146.49	15.8	0.285	55.6
T1-R1	2608.7	27.83	0	30.52	30.31	152.77	17.3	0.292	59.1
T1-R1	2723.0	29.30	0	32.73	30.31	161.84	21.6	0.329	65.9
T1-R1	2005.8	22.62	1	29.18	30.31	114.50	10.5	0.310	33.9
T1-R1	2093.7	23.26	1	29.93	30.31	121.07	11.2	0.298	37.5
T1-R1	2234.9	25.00	1	32.53	30.31	129.56	11.9	0.276	43.3
T1-R1	2302.0	25.45	1	32.75	30.31	134.02	12.5	0.272	46.1
T1-R1	2424.5	26.45	1	32.51	30.32	142.15	13.2	0.256	51.5
T1-R1	2504.9	27.30	1	33.94	30.31	148.58	16.1	0.287	55.9
T1-R1	2607.4	27.85	1	28.20	30.31	152.31	17.2	0.294	58.4
T1-R1	2752.7	29.30	1	31.53	30.31	161.29	21.6	0.326	66.1
T1-R2	2037.3	22.59	0	31.00	29.93	118.45	10.8	0.298	36.4
T1-R2	2091.2	23.34	0	32.32	29.92	122.57	11.4	0.295	38.8
T1-R2	2217.4	24.26	0	32.09	29.92	129.61	12.3	0.282	43.5
T1-R2	2287.3	25.20	0	32.05	29.92	136.23	13.0	0.275	47.2
T1-R2	2412.0	26.25	0	29.19	29.90	143.05	13.7	0.265	51.7
T1-R2	2539.6	27.06	0	28.61	29.90	149.99	15.2	0.268	57.0
T1-R2	2585.8	27.78	0	27.89	29.89	154.92	17.2	0.288	59.8
T1-R2	2684.7	28.70	0	26.44	29.90	159.85	21.5	0.338	63.7
T1-R2	2036.0	22.62	1	31.00	29.93	118.67	10.8	0.297	36.4
T1-R2	2067.8	23.47	1	32.00	29.92	122.76	11.3	0.295	38.4
T1-R2	2194.4	24.37	1	32.09	29.92	129.52	12.1	0.281	43.0
T1-R2	2302.5	25.17	1	31.44	29.92	135.78	12.7	0.269	47.2
T1-R2	2401.2	26.25	1	30.47	29.91	141.82	13.5	0.264	51.3
T1-R2	2507.3	27.10	1	28.25	29.90	150.23	15.1	0.268	56.2
T1-R2	2608.7	27.74	1	27.78	29.90	154.70	17.3	0.287	60.2
T1-R2	2668.8	28.72	1	25.98	29.90	159.12	21.6	0.344	62.9
T1-R7	2031.3	22.50	0	18.00	30.21	113.35	10.6	0.324	32.7
T1-R7	2117.6	23.41	0	20.52	30.21	121.02	11.3	0.308	36.8
T1-R7	2224.9	24.64	0	18.80	30.21	127.43	11.7	0.290	40.4
T1-R7	2290.7	25.73	0	19.50	30.22	132.93	12.0	0.276	43.5
T1-R7	2417.9	26.68	0	19.30	30.22	139.54	12.9	0.269	48.1
T1-R7	2506.1	26.85	0	21.07	30.22	146.28	14.3	0.271	52.7
T1-R7	2600.5	27.58	0	22.24	30.23	151.13	15.2	0.268	56.7
T1-R7	2742.9	29.50	0	20.81	30.23	159.79	20.7	0.329	62.9

T1-R7	2009.3	22.32	1	18.82	30.21	112.94	10.4	0.320	32.3
T1-R7	2128.7	23.33	1	20.01	30.21	120.35	11.3	0.309	36.7
T1-R7	2285.7	25.40	1	18.00	30.21	131.44	12.7	0.297	42.7
T1-R7	2304.0	25.68	1	18.48	30.21	131.99	12.8	0.295	43.3
T1-R7	2408.2	26.70	1	20.23	30.22	138.78	13.1	0.273	47.9
T1-R7	2519.3	26.82	1	21.00	30.22	146.48	14.7	0.278	53.0
T1-R7	2574.6	27.60	1	23.00	30.23	151.37	15.2	0.270	56.4
T1-R7	2743.4	29.50	1	22.06	30.23	159.69	20.6	0.327	63.2

MAGNET TEST RUNS

TEST -RUN	RPM	MAP inHg	TANK 0.0 Rt 1.0 Lt	CARB AIR deg C	AMBIENT inHg	TORQUE ft-lb	FUEL FLOW CORR'D	BSFC CORR'D kg/KW hr	POWER CORR'D kW hr
T1-R3	2012.0	23.25	0	29.04	30.30	116.17	10.7	0.311	34.5
T1-R3	2121.9	23.70	0	29.50	30.30	123.05	11.7	0.303	38.6
T1-R3	2241.6	24.75	0	29.52	30.30	129.57	12.3	0.286	42.9
T1-R3	2297.6	25.60	0	29.76	30.31	134.84	12.8	0.280	45.8
T1-R3	2423.5	26.45	0	29.27	30.31	140.74	14.0	0.278	50.4
T1-R3	2493.7	27.15	0	28.45	30.30	147.60	14.8	0.272	54.2
T1-R3	2587.9	27.95	0	29.04	30.31	153.17	16.5	0.282	58.5
T1-R3	2732.6	29.30	0	26.00	30.30	161.30	21.4	0.333	64.3
T1-R3	2056.8	23.08	1	29.50	30.30	116.67	10.8	0.306	35.5
T1-R3	2100.0	23.76	1	29.78	30.30	122.35	11.4	0.299	38.0
T1-R3	2216.5	24.84	1	29.50	30.30	130.77	12.1	0.283	42.8
T1-R3	2305.0	25.52	1	29.71	30.30	134.06	12.6	0.275	45.7
T1-R3	2388.4	26.55	1	29.63	30.30	140.65	13.4	0.270	49.7
T1-R3	2498.0	27.13	1	29.35	30.31	146.27	14.5	0.268	54.0
T1-R3	2578.9	27.93	1	28.50	30.30	152.47	16.3	0.282	57.9
T1-R3	2738.0	29.30	1	26.21	30.30	162.19	21.6	0.332	64.8
T1-R4	2049.5	22.46	0	30.00	30.33	115.91	10.7	0.305	35.1
T1-R4	2105.6	23.09	0	30.01	30.32	121.71	11.3	0.298	37.9
T1-R4	2199.9	24.10	0	30.08	30.32	127.80	11.8	0.282	41.6
T1-R4	2292.7	25.33	0	29.97	30.32	135.07	12.4	0.270	45.8
T1-R4	2398.8	26.24	0	29.84	30.32	140.58	13.6	0.273	49.8
T1-R4	2535.3	26.94	0	27.63	30.31	149.04	14.9	0.269	55.5
T1-R4	2614.6	27.70	0	28.37	30.31	152.99	16.3	0.277	58.9
T1-R4	2737.1	29.00	0	25.56	30.31	161.22	21.1	0.328	64.3
T1-R4	2001.9	22.72	1	30.00	30.33	117.71	10.5	0.302	34.9
T1-R4	2111.2	23.10	1	30.43	30.32	121.59	11.4	0.299	38.0
T1-R4	2189.8	24.12	1	30.12	30.32	127.68	11.7	0.283	41.4
T1-R4	2305.3	25.29	1	29.73	30.32	133.95	12.4	0.271	45.7
T1-R4	2406.6	26.20	1	29.24	30.31	140.85	13.2	0.264	50.0
T1-R4	2524.6	26.96	1	28.03	30.31	148.12	14.6	0.265	55.0
T1-R4	2608.2	27.75	1	28.02	30.31	153.41	16.2	0.275	58.8
T1-R4	2745.2	29.00	1	26.00	30.31	161.52	21.2	0.328	64.7
T1-R5	2300.9	25.30	0	27.83	30.05	135.27	12.5	0.270	46.2
T1-R5	2305.7	25.40	0	26.00	30.10	135.31	12.4	0.270	45.9
T1-R5	2305.7	25.40	0	27.00	30.07	135.98	12.4	0.269	46.3
T1-R5	2311.1	25.30	0	27.00	30.06	136.12	12.4	0.268	46.5
T1-R5	2312.7	25.30	0	27.00	30.06	134.52	12.4	0.270	45.8
T1-R5	2315.6	25.33	0	26.02	30.08	133.91	12.4	0.273	45.6
T1-R5	2319.4	25.30	0	27.00	30.06	133.73	12.4	0.271	45.8
T1-R5	2322.7	25.30	0	26.00	30.08	134.75	12.4	0.270	46.0
T1-R5	2333.2	25.30	0	26.00	30.09	133.22	12.6	0.276	45.7
T1-R5	2727.5	28.90	0	24.11	30.10	157.70	20.8	0.331	62.8

T1-R5	2299.3	25.32	1	26.98	30.06	136.37	12.4	0.267	46.3
T1-R5	2300.0	25.40	1	26.00	30.08	135.35	12.3	0.268	45.8
T1-R5	2306.4	25.40	1	26.00	30.09	135.57	12.4	0.269	46.0
T1-R5	2310.8	25.30	1	27.00	30.06	134.90	12.4	0.269	46.1
T1-R5	2320.1	25.30	1	26.98	30.07	135.55	12.5	0.269	46.5
T1-R5	2320.5	25.31	1	25.98	30.09	134.24	12.3	0.269	45.8
T1-R5	2321.2	25.28	1	27.00	30.06	132.96	12.3	0.270	45.6
T1-R5	2325.3	25.34	1	25.89	30.10	133.82	12.4	0.271	45.7
T1-R5	2331.0	25.30	1	26.71	30.07	133.62	12.3	0.268	46.0
T1-R5	2718.3	28.90	1	23.97	30.10	160.27	21.1	0.332	63.6
T1-R6	2032.6	22.79	0	29.41	30.21	113.78	10.7	0.312	34.3
T1-R6	2128.2	23.71	0	30.00	30.21	124.02	11.4	0.290	39.2
T1-R6	2222.9	24.57	0	30.01	30.21	129.58	12.0	0.281	42.8
T1-R6	2315.6	25.55	0	30.23	30.21	135.01	12.5	0.270	46.5
T1-R6	2415.0	26.44	0	30.09	30.21	139.72	13.5	0.270	50.2
T1-R6	2535.4	27.31	0	29.36	30.20	146.31	14.8	0.270	55.0
T1-R6	2601.0	28.00	0	29.03	30.20	151.82	15.8	0.270	58.5
T1-R6	2775.0	29.60	0	28.00	30.20	160.95	21.2	0.322	65.9
T1-R6	2018.9	22.86	1	29.65	30.21	115.37	10.6	0.307	34.6
T1-R6	2116.5	23.50	1	30.00	30.21	122.41	11.6	0.300	38.5
T1-R6	2228.4	24.54	1	30.05	30.21	129.24	12.1	0.282	42.8
T1-R6	2317.4	25.55	1	30.00	30.21	135.14	12.5	0.269	46.5
T1-R6	2419.1	26.35	1	30.00	30.20	140.70	13.8	0.273	50.6
T1-R6	2518.6	27.36	1	29.53	30.20	146.51	14.9	0.273	54.8
T1-R6	2616.6	28.00	1	29.00	30.20	151.59	15.8	0.269	58.7
T1-R6	2759.9	29.60	1	28.00	30.20	161.68	21.3	0.323	65.8

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