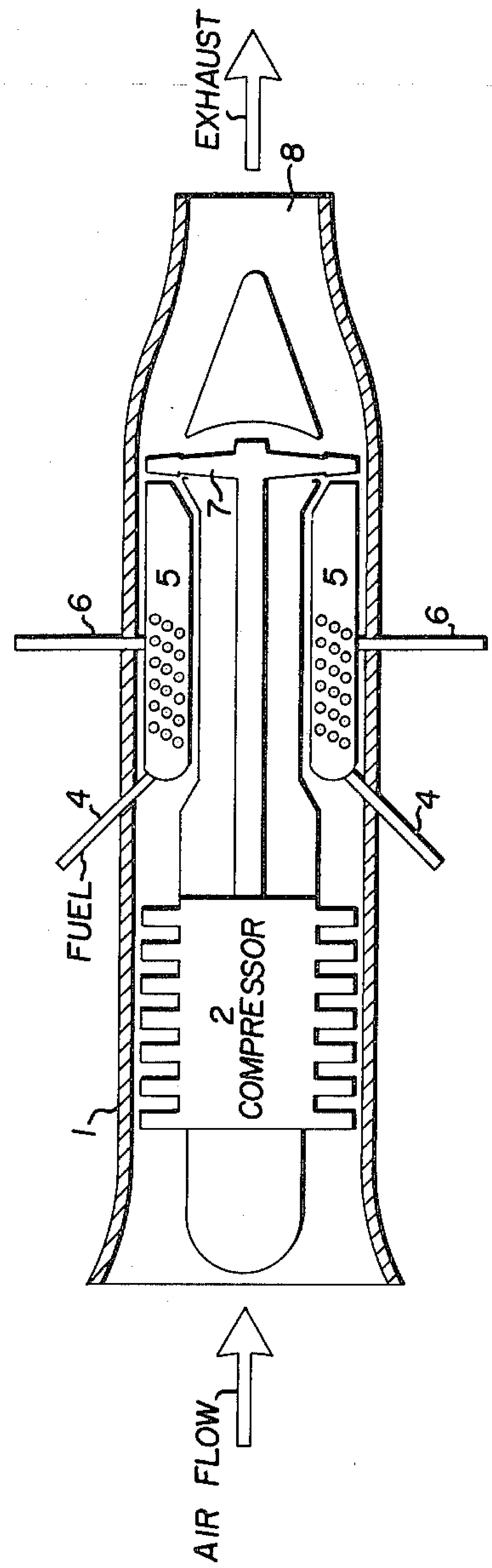
Sept. 20, 1960 T. B. WASSERBACH ET AL 2,952,969

AVIATION TURBO FUEL

Filed May 26, 1955



Theodore B. Wasserbach
Matthew W. France
Inventors

By W. O. Heilman Attorney

United States Patent Office

2,952,969

Patented Sept. 20, 1960

2,952,969

AVIATION TURBO FUEL

Theodore B. Wasserbach, Cranford, and Matthew W. France, Elizabeth, N.J., assignors to Esso Research and Engineering Company, a corporation of Delaware

Filed May 26, 1955, Ser. No. 511,261

6 Claims. (Cl. 60—35.4)

The present invention is concerned with an improved aviation fuel and in particular with a turbo jet fuel that will not plug the filters in airplane fuel systems at relatively low temperatures. The invention is more particularly concerned with an improved method of operating a jet propelled aircraft by utilizing the jet fuel composition of the present invention. The present application is a continuation-in-part of application Serial No. 205,216, filed January 9, 1951, for Wasserbach et al., entitled "Aviation Turbo Fuel," and now abandoned.

In accordance with the present invention improved high quality turbo jet fuels are secured by utilizing a particular addition agent which is selected from the class of compounds represented by the formula

$$[\mathrm{H(O{-}CH_2CH_2)_xO}]_y{-}\mathrm{X}{-}\mathrm{O}{-}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}{-}\mathrm{R}$$

wherein x and y are integers, wherein X represents a residue of a polyhydric alcohol and R represents a hydrocarbon group having from 11 to 21 carbon atoms per molecule. Preferred compounds are mono-oleates, for example sorbitan mono-oleate and its polyether derivatives produced by reacting sorbitan mono-oleate with ethylene oxide. A particularly desirable mono-oleate comprises polyethylene glycol mono-oleate wherein x equals 6; y equals 1 and which compound is represented by the formula

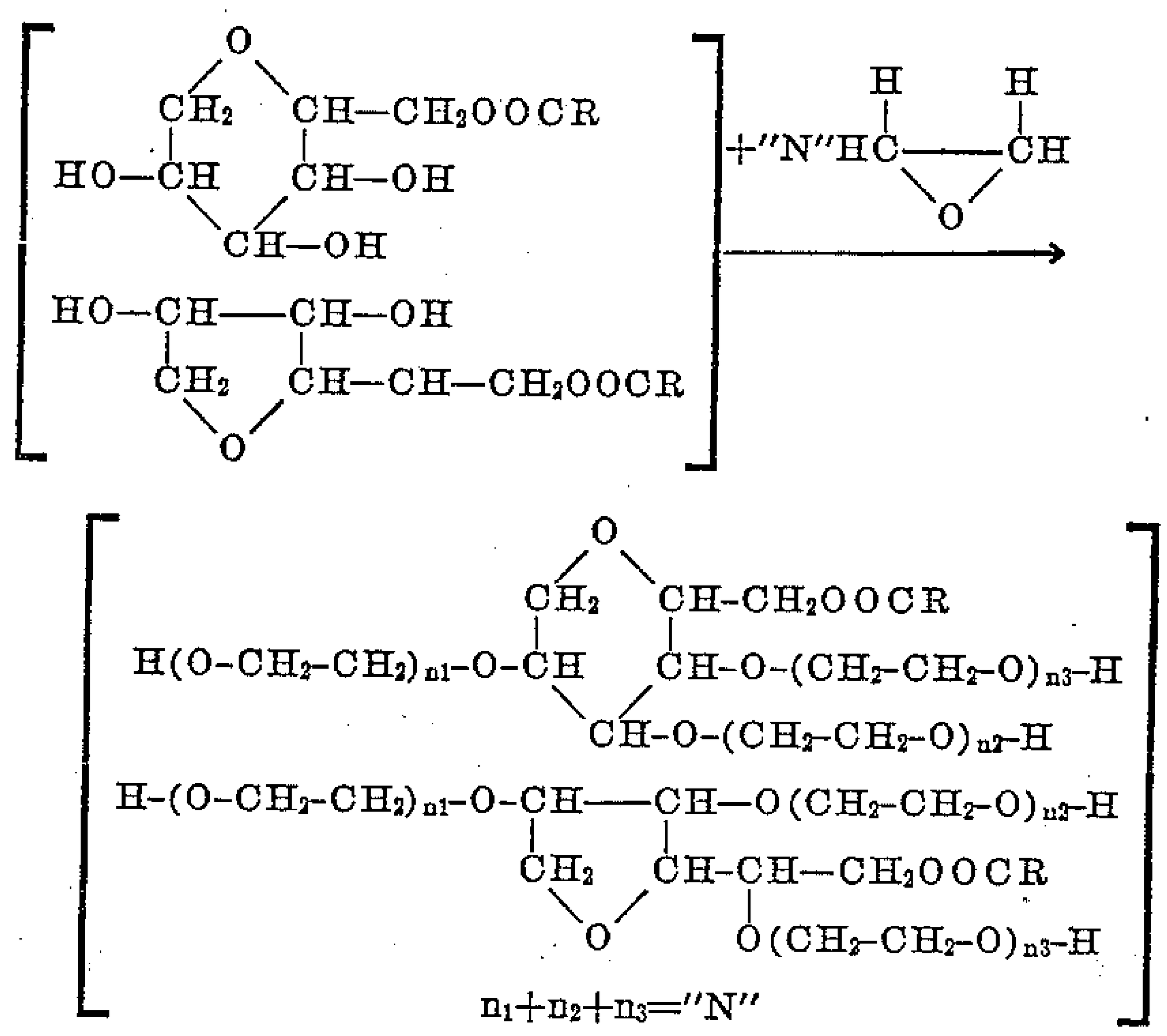
$$\mathrm{H(O{-}CH_2{\cdot}CH_2)_6O}{-}\underset{\mathrm{H}}{\overset{\mathrm{H}}{\mathrm{C}}}{-}\underset{\mathrm{H}}{\overset{\mathrm{H}}{\mathrm{C}}}{-}\mathrm{O}{-}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}{-}\mathrm{C_{17}H_{33}}$$

It is well known in the art to utilize various types of turbo jet fuels. However, one of the most severe limitations to maximum availability of turbo fuel is the freezing point specification which is considered necessary in order to insure fuel flow under high altitude, low temperature conditions. In order to provide fuels that have very low freezing points, various processes such as solvent extraction and the like have been suggested. On the other hand, it has been found that at temperatures well above the specified hydrocarbon freezing point, difficulties such as plugging of fuel filters, are often encountered due to freezing out of dissolved or entrained water. In a normal type of turbo jet engine, compressed air is passed into a combustion chamber wherein fuel under pressure is injected into the flowing air. This fuel is introduced by means of a pump. Prior to passing the fuel through the pump the fuel is passed through a micronic or equivalent type filter which is necessary in order to protect the fuel nozzle. Under low temperature conditions ice from water dissolved or entrained in the fuel forms on the filter, causing fuel flow failure and engine stoppage. It has, however, now been discovered that when a certain class of compounds are added, unexpected desirable results are secured with respect to this problem of icing of the filter.

The additive anti-icing agents of the present invention are selected from the class of compounds represented by the formula

$$[\mathrm{H(O{-}CH_2{-}CH_2)_xO}]_y{-}\mathrm{X}{-}\mathrm{O}{-}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}{-}\mathrm{R}$$

wherein x is an integer between 1 and 10, y is an integer one less than the number of hydroxy groups in a polyhydric alcohol which has two to six hydroxy groups and of which X represents the residue radical, and R represents a hydrocarbon group having from 11 to 21 carbon atoms. Very desirable agents comprise sorbitan mono acid esters and in particular the polyoxyethylene ethers thereof, which compounds are produced by reacting sorbitan mono acid esters with ethylene oxide in accordance with the following:



wherein R represents the hydrocarbon radical of a relatively long chain (C_{12} to C_{22}) fatty acid, as for example lauric, palmitic, oleic, stearic or behenic acid, or mixtures thereof. The preferred compounds are the mono-oleates. The polyoxy ethylene ethers of sorbitan mono-oleate preferably contain from 2 to 10 carbon atoms in each ether radical. Other desirable additives are polyethylene glycol derivatives of long chain fatty acids represented by the formula

$$\mathrm{H(O{-}CH_2{-}CH_2)_x{-}O{-}CH_2{-}CH_2{-}O}{-}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}{-}\mathrm{R}$$

wherein x and R have the same meaning as above. These compounds can be prepared by esterifying one mole of polyethylene glycol with one mole of a fatty acid. A particularly desirable compound is the polyethylene glycol ester of oleic acid having the formula

$$\mathrm{H(O{-}CH_2{-}CH_2)_6{-}O{-}CH_2{-}CH_2{-}O}{-}\overset{\mathrm{O}}{\overset{\|}{\mathrm{C}}}{-}\mathrm{C_{17}H_{33}}$$

The present invention may be readily understood by the following examples illustrating the same.

EXAMPLE I

Various fuels were tested with the additives of the present invention in order to determine the filterability of the fuels at very low temperatures using a 10-micron filter made of paper or felt and having an area of 0.4 sq. in. In carrying out the tests, the fuel was chilled to the desired low temperature and was pumped through the filter until plugging occurred. The results are shown in Table I.

Table I.—Effect of additives on the low temperature filter plugging tendencies of hydrocarbon fuels

[Fuels water saturated* at room temperature, 2 gallon fuel charge—0.05 wt. percent additive, 10 micron Skinner paper type filter]

Fuel, Vol. Percent	90 Heptane/10 Toluene						JP-3** Turbo Fuel	
Fuel Freezing Pt., ° F	<−76						<−76	
Fuel Temp., ° F	−20			−50			−50	
Additive	None	(1)	(2)	None	(1)	(2)	None	(2)
Time to Plugging, Min.:(3)								
Additive added to fuel just prior to run	9	>46	>44	4	>47	>46	11	>43
Fuel containing additive stood over water for 24 hrs	(4)	--------	>40	--------	>43	>40	--------	>43

* About 0.005 vol. percent.
** U.S. Specification MIL 5624.
1 Polyoxyethylene ethers of sorbitan mono-oleate (containing 4 oxyethylene groups).
2 Polyoxyethylene derivative of long chain fatty acid (oleic acid) (containing 6 oxyethylene groups).
3 Time in minutes to the moment at which desired flow rate of 150 cc. per minute could not be maintained with a pressure of 22 ins. of mercury absolute.
4 Fuel agitated periodically with water.

Thus, it is evident from the above that plugging of engine filters due to the freezing out of dissolved water can be prevented by using the additives of the present invention. These additives have the unusual advantage over other active agents that these materials can be added to fuel at a refinery source without bringing excess water into the fuel due to storage over water for prolonged periods.

EXAMPLE II

Sorbitan mono-oleate was also found to be an effective anti-icing agent, as will be observed from the data shown in the following table:

Table II.—Effect of surface active agents on the plugging of turbo engine fuel filters due to the freezing out of dissolved water

[10 micron wool yarn filter, 0.4 square inch area, flow rate of 150 cc./minute at −20° F. fuel temperature]

Fuel	Heptane (water saturated at room temp.).	
Additive	None	Sorbitan mono-oleate.
Concentration, Wt. Percent	----------	0.02.
Time to Plugging, Mins	13 (Aver. of 3 runs).	>46 (no plugging).
After standing over water for 24 hrs.	----------	9.

It will be observed, however, that for maximum effectiveness, this particular agent should be employed in fuels which are to be stored in dry tanks.

EXAMPLE III

A number of operations were conducted using various concentrations of sorbitan mono-oleate in a fuel for the prevention of filter icing at −20° F. The results of these tests are as follows:

Sorbitan mono-oleate wt. percent:	Time to plug filter, minutes
None	9
0.01	14
0.05	>46
0.08	>46

From the above data it is evident that the amount of additive used may vary appreciably but is in the range from 0.02 to 0.2% by weight. Preferred concentrations are in the range from 0.05 to 0.1% by weight.

These additives are adapted particularly for low temperature turbo jet fuels boiling generally in the range from about 100 to 600° F. In general, these fuels comply with the JP-1 and JP-3 grades of U.S. Specification MIL-F-5616 and 5624 respectively. They are also applicable to other fuels particularly JP-4, which has 2 to 3 p.s.i.a. Reid vapor pressure. These fuels may all be employed in ram-jet engines as well as in turbo-jets.

Some typical inspections of these fuels are:

	JP-1	JP-3
Aromatics, Vol. percent	<20	<25
Gravity, ° API	>35	45-63
Reid V.P. #/Sq. In	----------	5.0-7.0
ASTM Distillation (at 4-5 cc./Min.):		
10% Evap. at ° F	>410	----------
40% Evap. at ° F	----------	----------
50% Evap. at ° F	----------	----------
90% Evap. at ° F	>490	>400
End Point, ° F	<572	<600
Sum of 10% +50% Evap. Pts., ° F	----------	----------
Distillation Loss, percent	<1.5	<1.5
Resid. After Dist., percent	<1.5	<1.5

These turbo-jet fuels are petroleum naphthas less volatile than gasoline and more volatile than heating oil, diesel fuel or other fuel oils. For instance, gasoline typically has a Reid vapor pressure of at least 6 and preferably above 7 p.s.i.a., an initial boiling-point of 90° F. and an end-point of 420° F. by ASTM method D-86; and heating oil typically has a flash-point above 150° F., an initial boiling point of 390° F. and an end-point of 675° F.; but JP-3 has an initial boiling point of about 150° F. and an end-point of 540° F. The volatility limitations of turbo-jet fuel are critical at the flash-point and at the 90% point in the distillation. The flash-point is below 130° F. for the least volatile grade, JP-1, and the 90% point must be between 400° F. and 490° F.; whereas gasoline has its 90% point below 365° F. and preferably below 356° F. as may be seen in specifications in MIL-G-3056 and VV-M-561 of United States Department of Defense and Federal Supply Service respectively.

Turbo-jet fuels are required to be completely free of sludge-forming constituents. The specifications require the bromine number to be less than 30 centigrams per gram, thus substantially limiting the content of unsaturated hydrocarbons such as are produced by cracking processes. Furthermore, the content of unstable constituents susceptible of forming sludge or gum is controlled by requiring the gum content to be less than 10 milligrams per 100 cc. Consequently, turbo-jet fuels normally contain less than 10% by volume of cracked stocks.

The method of operating an engine in accordance with this invention is evident from the accompanying drawing in which the single figure shows a diagrammatical sketch of a jet turbine engine. Air is introduced into engine 1 through air compressor 2. The compressed air flows into the combustion chamber 5 wherein it is mixed with fuel introduced by means of lines 4. The fuel filters are installed in lines 4, which terminate in spray-nozzles. The hot gases flow through turbine 7 and are jetted through tail-pipe 8 as shown.

What is claimed is:

1. The method of operating the jet engine of a jet propelled aircraft at low temperatures which comprises operating said engine with a hydrocarbon jet fuel containing from 0.02 to 0.2 weight percent of a compound selected from the class consisting of the sorbitan monoesters, the polyoxyethylene ethers of the sorbitan monoesters, and the polyethylene glycol monoesters, of fatty acids having from 12 to 22 carbon atoms, whereby ice formation and resultant fuel filter plugging within the fuel system of said engine are prevented.

2. A fuel composition for use in a jet engine which consists of a mixture of hydrocarbons boiling within the range of from about 100° F. to 600° F. and containing from 0.02 to 0.2 weight percent of a compound selected from the class consisting of the sorbitan monoesters, the polyethylene glycol monoesters, and the polyoxyethylene ethers of the sorbitan monoesters, of fatty acids having from 12 to 22 carbon atoms.

3. Fuel composition as defined by claim 2 wherein said compound is employed in a concentration within the range of from 0.05 to 0.1 percent by weight.

4. A fuel composition for use in a jet engine which consists of a mixture of hydrocarbons boiling within the range of from about 100° to 600° F. and containing from 0.02 to 0.2 wt. percent of a sorbitan mono-oleate.

5. A fuel composition for use in a jet engine which consists of a mixture of hydrocarbons boiling within the range of from about 100° to 600° F. and containing from 0.02 to 0.2 wt. percent of a polyethylene glycol mono-oleate.

6. A fuel composition for use in a jet engine which consists of a mixture of hydrocarbons boiling within the range of from about 100° to 600° F. and containing from 0.02 to 0.2 wt. percent of a polyoxyethylene ether of a sorbitan mono-oleate.

References Cited in the file of this patent

UNITED STATES PATENTS

2,548,347	Caron et al.	Apr. 10, 1951
2,599,338	Lifson et al.	June 3, 1952
2,858,201	Newman	Oct. 28, 1958

OTHER REFERENCES

Murray: "The Oil and Gas Journal," Mar. 29, 1951, pages 218, 219, 271–281.