



## Divine's CO<sub>2</sub> Absorber of 1867

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### ABSTRACT

Chemist and inventor Silas R. Divine (1838–1912) sold ammonium nitrate and other anesthesia supplies in New York City. He offered a carbon dioxide absorber for the purpose of rebreathing nitrous oxide. Like his colleague Gardner Q. Colton, he denied the need for nitrous oxide to be supplemented with O<sub>2</sub> gas.

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Inhaled nitrous oxide anesthesia was proposed by British chemist Humphry Davy (1778–1829) in 1800 and was used as an aid to dental extraction in Hartford, Connecticut, in 1844.<sup>1,2</sup> However, its attempted demonstration in Boston, Massachusetts, was not convincing and was denounced as a “humbug affair” in 1845.<sup>3</sup> One of the early impediments to the widespread application of nitrous anesthesia was that it was not commercially available as a compressed gas.

In the 1860s, painless dental practitioners in New York City were each generating their nitrous oxide gas on-site from solid granules of ammonium nitrate. Chemist Silas Reynolds Divine (May 18, 1838 to September 20, 1912) was a supplier of that salt (Figure 1).<sup>4</sup> He published a detailed booklet entitled *Directions for Making and Administering Nitrous Oxide* in 1867 (Figure 2).<sup>4–6</sup> It was intended for customers and contained 26 pages of text and 7 pages of interesting advertisements. For instance, there were directions for heating ammonium nitrate and for removing impurities from the evolved anesthetic gas (Figure 3). One can conclude from the booklet that early nitrous anesthesia entailed considerable effort and ability in chemistry.

Nitrous oxide anesthesia was a popular aid to dentistry in New York City in the 1860s because of the efforts of Gardner Quincy Colton (1814–1898),<sup>2</sup> who was a competent chemist and became a colleague and customer of Divine.<sup>4</sup> As a laughing gas showman in 1844, Colton had introduced nitrous oxide to dentist Horace Wells (1815–1848). Wells recognized its potential dental anesthetic value and prompted Colton to administer nitrous to him for an extraction. Sadly, Wells did not successfully champion nitrous anesthesia in his few and troubled remaining years. Colton turned his energies to the California Gold Rush in 1849, but, continuing to seek his fortune, he launched a prosperous painless dental clinic in New York City in 1863.<sup>2,7,8</sup>

### Gasometer

Freshly prepared nitrous oxide was stored at nearly atmospheric pressure in either a rubber bag or else in a metal container known as a gasometer. In a gasometer, a metal can was suspended mouth-down into a liquid. The gas-free can rose as it was filled with added gas. The weight of the can was opposed by a pulley and counterweight. In his classic monograph on laughing gas, Davy described a volumetrically accurate gasometer for inhaled agents in 1800 (Figure 4).<sup>1</sup>

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S. R. DIVINE'S  
GRANULATED, FUSED AND CRYSTALLIZED  
**NITRATE OF AMMONIA**

Is put up in hermetically sealed Packages, (or to order as desired,) containing 5 lbs. each,  
and is sold at the following Prices :

By the Single Can, or less than Half Doz., . . . . .	75c. per lb.
“ Half Doz. “ “ One Doz. . . . .	70c. “
“ One Doz. “ “ Two Doz. . . . .	65c. “
“ Two Doz. or more, . . . . .	60c. “

For shipment, the cans will be well packed in cases, containing each one-half dozen, one  
dozen, and two dozen cans, and cases will be charged as follows :

Half Doz. Case, . . . . .	50c.
One Doz. Case, . . . . .	75c.
Two Doz. Case, . . . . .	100c.

**ENOCH MORGAN'S SONS, Agents,**  
211 WASHINGTON ST., NEW YORK.

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NEW YORK, June, 1865.

This is to certify that the Nitrate of Ammonia now being furnished me by Mr. S. R. Divine  
is an unexceptionable article for making Nitrous Oxide Gas.

G. Q. COLTON.

MINING AND ASSAY OFFICE AND CHEMICAL LABORATORY,  
57 BROADWAY, N. Y., August, 22, 1866.

MR. S. R. DIVINE.

*Dear Sir:* I have made a thorough qualitative analysis of the Nitrate of Ammonia manu-  
factured by you, and am pleased to report that for purity it is unsurpassed, if not unequalled,  
by any in the market. It leaves but an inappreciable trace of residue on incineration, and is  
free from iron, and also from sulphates and chlorides with which the crude salt is frequently  
contaminated. For all practical purposes it may be regarded as being *absolutely pure*. Its  
purity renders it very valuable as a source of Nitrous Oxide Gas, so extensively used by sur-  
geons and dentists.

Respectfully yours,  
C. ELTON BUCK,  
*Analytical and Consulting Chemist.*

COOPER INSTITUTE, August 23, 1866.

Having prepared the Nitrous Oxide Gas for the Colton Dental Association for a long time,  
and having tried every article of Nitrate of Ammonia in market, as well as having manu-  
factured it myself, I recommend that made by S. R. Divine as the best I have yet used.

O. N. SNOW.

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S. R. DIVINE, M. D.,  
**Analytical and Manufacturing Chemist.**  
*Consultations on Arts and Manufactures; Analyses of Minerals, Commercial  
Articles, &c.; Assistance rendered in perfecting New Inventions, and in  
all business requiring the aid of Chemistry.*  
No. 211 WASHINGTON STREET,  
New York.

**Fig. 1.** Chemist S.R. Divine, M.D., offered ammonium nitrate salt for 60 to 100 cents per pound.<sup>4</sup> His colleague and customer Gardner Q. Colton praised Mister Divine's "unexceptionable article for making Nitrous Oxide Gas". Divine promised a pound of the salt to yield 37 gal of the gas. The Boston Medical Library copy of the Divine booklet has been digitally scanned for free public access via [archive.org](http://archive.org). The entrepreneurial publisher of the booklet, Enoch Morgan's Sons of New York City, was the sales agent for Divine's Pure Nitrate of Ammonia. From 1869 Morgan's Sons offered a soap they named Sapolio, deemed "probably the world's best-advertised product" of 1899-1905 by the business section of *Time* magazine on April 6, 1936.

Davy used elemental mercury (quicksilver) as the liquid over which  $N_2O$  was stored. The mercury was expensive but provided a good seal as it resists solution and diffusion of gases. Unfortunately,

Davy thus inhaled appreciably toxic traces of mercury vapor from his gas container. Unlike Davy, painless dentists used leaky but inexpensive gasometers with water as the liquid phase (Figure 5).<sup>9</sup>

# DIVINE'S INHALER.

(Manufactured under Letters Patent.)

This Inhaler is constructed with a chamber containing a sponge moistened with chemicals that entirely remove

## CARBONIC ACID, ANIMALCULÆ,

and Fetid Exhalations, and the bag never becomes corrupt by breathing back and forth. The sponge can be removed and rinsed, every time it is used, by simply opening the chamber. With this Inhaler there is a perfect economy of gas without danger of asphyxiating the patient. The chamber is of metal and the mouthpiece of hard rubber. No Valves to get out of order.

### PRICES.

Plain and Burnished,	- - - - -	\$9.00.
Silver Plated,	- - - - -	12.00.

For Sale by Dental Dealers.

# DIVINE'S GASOMETER.

(PATENT PENDING.)

Made entirely of sheet metal—50 gallons capacity. When used the cistern is filled with water containing chemicals that immediately purify Nitrous Oxide, without the use of washing bottles. The simplest apparatus yet devised, and perfectly effective.

Price, - - - - - \$45.00.

For Sale by Dental Dealers.

Fig. 2. Advertisements for Divine's inhaler/scrubber and for his gasometer.<sup>4</sup> The scrubber removed CO<sub>2</sub> and also "animalculæ" (microbes).<sup>5,6</sup>

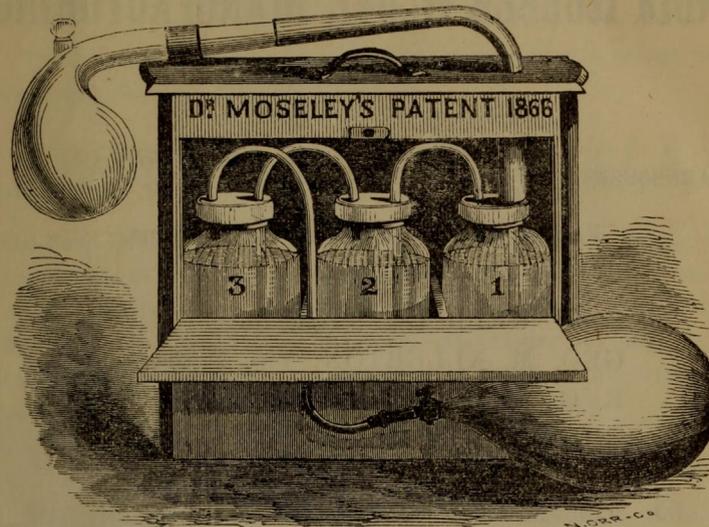
## Absorber

Divine advertised a rebreathing inhaler of his design, containing a CO<sub>2</sub> scrubber (Figure 2). Although the scrubber would reduce waste

of nitrous oxide and possibly reduce sales of ammonium nitrate, there would be sales of CO<sub>2</sub> absorbent.

The inhaler/scrubber had no valves. An alkali-moistened sponge was interposed between the gas reservoir and the patient. The

DR. CHARLES H. MOSELEY'S  
PATENT  
**Nitrous Oxide Gas Generator.**



The attention of the profession of Dental Surgeons is respectfully called to this Patent Nitrous Oxide Gas Generator, with or without Gasometer, combining Compactness, Simplicity, and Economy, and affording a ready means of producing pure Nitrous Oxide Gas in fifteen minutes' notice, ready for inhaling. For full particulars send for circulars.

LIST OF PRICES.

Gas Generator, No. 3, mahogany case, latest improvements,	\$25 00
“ No. 2, “ “ plain, latest “	20 00
“ No. 1, plain whitewood case, . . . . .	15 00
Gasometer, 40 Gallon capacity, . . . . .	30 00
“ 50 “ “ . . . . .	35 00
“ 60 “ “ . . . . .	40 00

Rubber Bags of all sizes, best quality, at the lowest market prices; also all the supplies, including Chemicals for Generators; Rubber Mouth-pieces, plain and with valves; Fused Nitrate of Ammonia; and Retorts of all sizes, at the lowest market prices, at retail or quantity. Testimonials are ample, as over three hundred Generators are now in use by the profession.

The attention of Dentists is particularly called to my manufacture of a new LIGHT RUBBER, stamped EXCELSIOR RUBBER, price \$4 00 per pound; also, to my METALLIC COMPOSITION VULCANITE SOLDER, for repairing broken sets of teeth. Manufactured by the inventor,

CHARLES H. MOSELEY,

166 & 168 Grand Street, Brooklyn, N. Y.

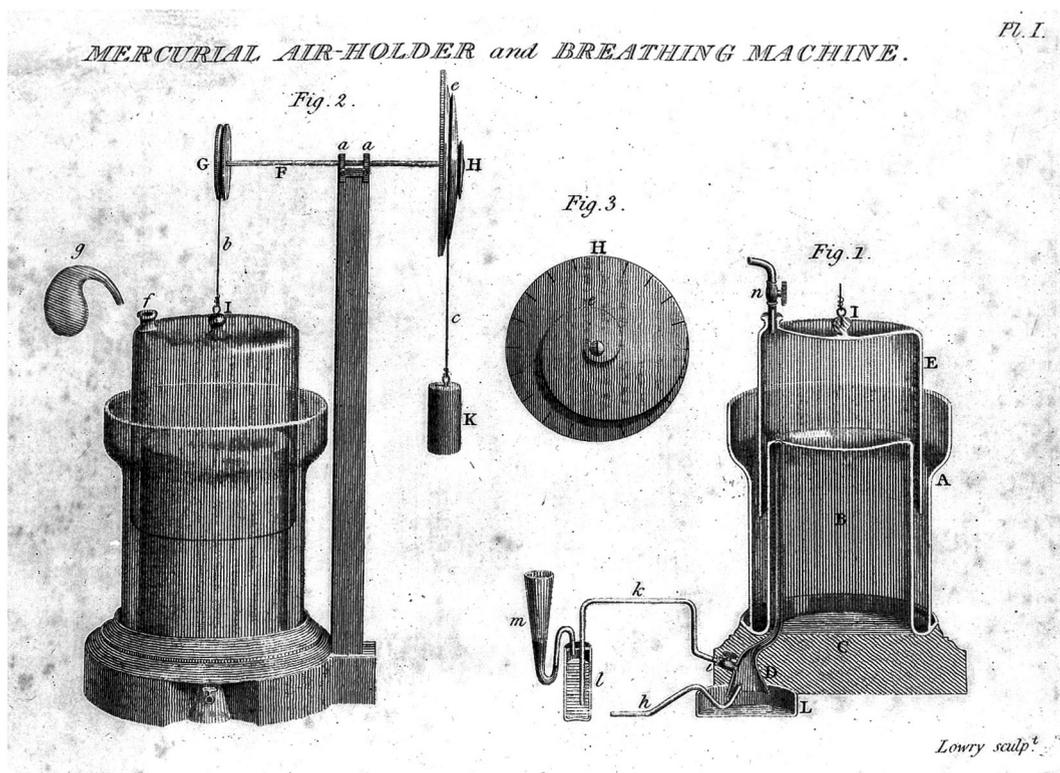
Orders sent promptly by Express, C. O. D.

**Fig. 3.** Divine advertised the nitrous oxide generator of Brooklyn dentist Charles H. Moseley (1828-1904). The bulb on the upper left is a glass “retort” that held ammonium nitrate salt. The salt was heated so as to release gas at a moderate rate. Overheating carried risk of explosion. Glass was required, rather than metal, because the salt and its fumes are acidic. The evolved gas passed through three bottles. The first trapped  $H_2O$  that was produced in twice the molecular amount of the  $N_2O$  coming from the  $NH_4NO_3$ . Another bottle destroyed nitric oxide by means of an aqueous solution of iron sulfate. The other captured nitric and nitrous acids with aqueous potassium hydroxide. The gas leaving the third bottle is shown filling a rubber bag at the bottom. Alternatively, the gas could be directed into a metallic gas holder known as a gasometer. Federal patent 54,389 was granted on May 1, 1866.

reservoir could be a bag of gas or else an ambient-pressure gasometer (Figure 2).

Ralph Milton Waters (1883-1979) used a to-and-fro scrubber to conserve cyclopropane in the 1930s.<sup>10,11</sup> However, Waters

added oxygen to the cyclopropane gas. Divine did not add oxygen gas but avowed “no danger of asphyxiation.” Sad to say, he propagated the false belief of Colton that the O atom of the  $N_2O$  molecule meets the human need for oxygen gas.<sup>7,8,12</sup> Dentists would have



**Fig. 4.** Davy's gasometer, or "mercurial air holder and breathing machine" of 1800.<sup>1</sup> A steel can was inverted over liquid mercury. The weight of the can was balanced by a pulley and counterweight. The can would lose weight as it sank more deeply into the liquid mercury during removal of gas. However, the cable to the counterweight wound around a spiral track in the suspending disk (shown). Ingeniously, the counterweight thus pulled less strongly as the can submerged. The gas holder was suitable for spirometry. The bulbous glass object on the left is a retort such as would be used to heat ammonium nitrate into crude nitrous oxide gas, and it indicates a port. Sadly, this device would contain a volumetrically unimportant but appreciably toxic concentration of mercury vapor in its gas reservoir. Liquid mercury was chosen by Davy because ordinary gases are virtually insoluble in it. The diagram is the frontispiece of the Davy monograph on laughing gas.<sup>1</sup> A scan of the book is offered by the Wood Library-Museum of Anesthesiology at [https://www.woodlibrarymuseum.org/library/pdf/s\\_ADVO.pdf](https://www.woodlibrarymuseum.org/library/pdf/s_ADVO.pdf).

been reluctant to supplement  $N_2O$  with  $O_2$  for fear of diluting the weak anesthetic power of the nitrous. (Even 100%  $N_2O$  does not ensure surgical immobility.) Furthermore, concentrated  $O_2$  gas was expensive in 1867 as it was not yet practical to isolate it from air.

## Hygiene

Infectious organisms were not accepted as possibilities by all practitioners in 1867, which was the year in which Joseph Lister (1827–1912) first called for antiseptic/aseptic surgery in the face of considerable opposition.<sup>13,14</sup> Divine evinced recognition that dangerous "animalcula" (microbes) could be transmitted from patient to patient (Figure 2).<sup>4</sup> The term *animalcula* had been applied by Dutch microscopist Antonie van Leeuwenhoek (1632–1723) to motile microorganisms such as spirochetes from dental plaque.<sup>5</sup> It was also employed by French microbiologist Louis Pasteur (1822–1895).<sup>6</sup> Divine offered no proof but pointed out that his scrubber would intercept microbes, and he recommended disinfection of anesthesia equipment.

Interestingly, the Divine booklet included an advertisement from Goodyear's India Rubber Glove Manufacturing Company for diverse rubber goods for dentistry (Figure 6). They did not list gloves for dentists, but they were to supply rubber gloves to innovative American surgeon William Stewart Halsted (1852–1922) in 1899.<sup>14</sup>

## Divine

Silas Reynolds Divine was born in Divine Corners, in upstate New York. The town was named for his forebears. Divine, his wife, and two sons lived in New York throughout his life. He attended a high school in Liberty, NY, taught school for a brief period,<sup>15</sup> and was awarded an honorary medical degree in 1865 by the New York Hygeio-Therapeutic College.<sup>16</sup> Operating from 1857–1867, the College was originally known as the New York Hydropathic School when it was opened in 1853 by Russell Thacher Trall (1812–1877), and it became the "water-cure center of the United States." The school's "decided informality" led to the awarding of "questionable" degrees.<sup>17</sup> The events leading to Divine's honorary degree have not been ascertained. He was Professor Divine to *The New York Times*.<sup>18</sup> In 1867 he joined the Lyceum of Natural History, re-named the New York Academy of Sciences in 1876.

Using Enoch Morgan's Sons in New York City as agents (Figure 1),<sup>4</sup> he described himself as "S.R. Divine, M.D., Analytical and Manufacturing Chemist." He offered "Consultations on Arts and Manufactures; Analyses of Minerals, Commercial Articles, &c.; Assistance rendered in perfecting New Inventions, and in all business requiring the aid of Chemistry." He was best known for his manufacture of chemical explosives.<sup>15,18</sup> In this regard, ammonium nitrate is highly explosive when mixed with hydrocarbons, and many high explosives are manufactured from nitrate. Silver nitrate and nitrocellulose (collodion) were used in photography, another area of Divine's expertise.<sup>19</sup>

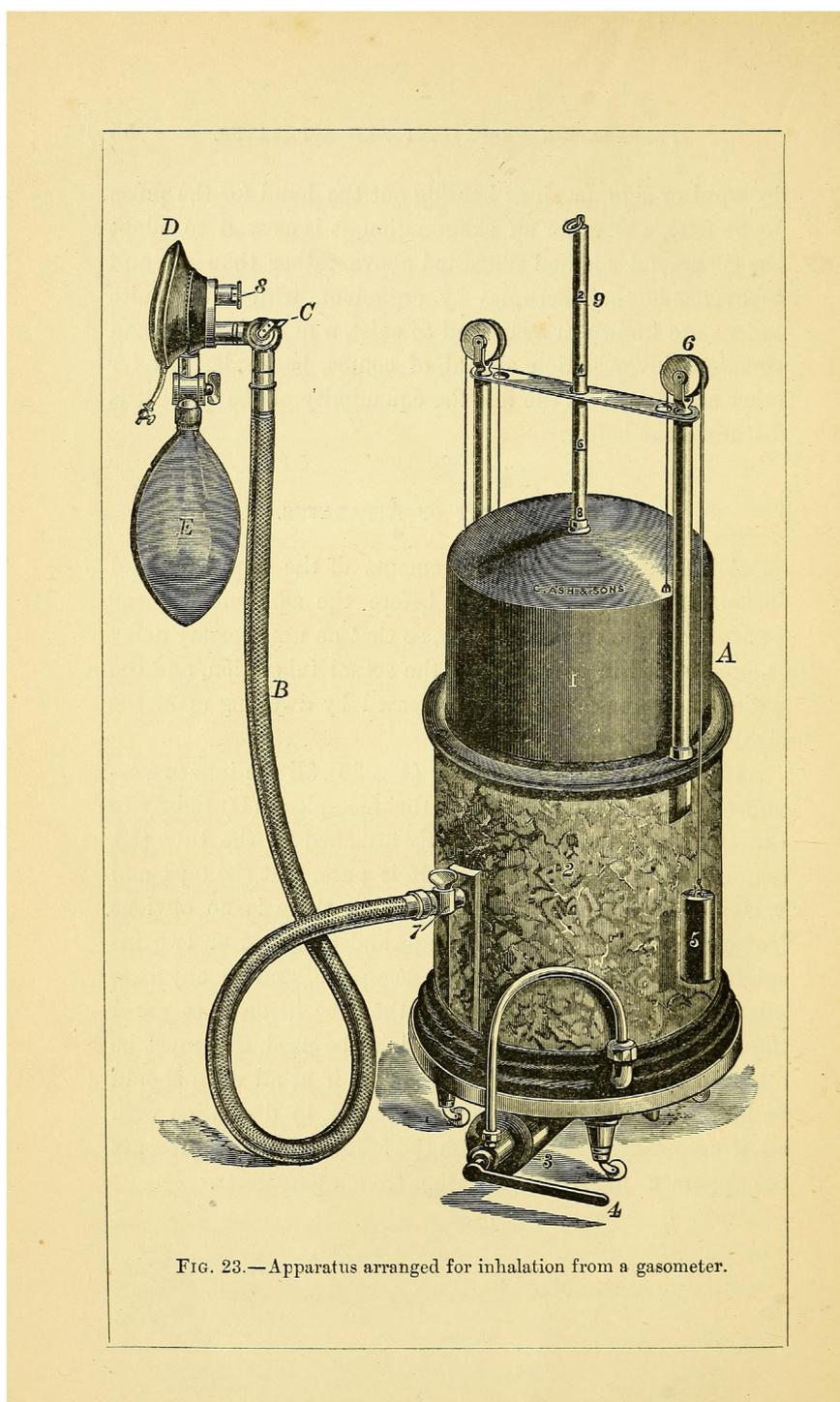


FIG. 23.—Apparatus arranged for inhalation from a gasometer.

**Fig. 5.** A gasometer of 1888.<sup>9</sup> A bag and mask are attached. Divine pointed out that, in 1867, some dentists simply but wastefully displaced the water from a wooden barrel with a stream of freshly generated nitrous oxide gas.<sup>4</sup> Most dentists used steel gasometers that stored nitrous oxide gas over water for up to a week or so. Since nitrous oxide is highly soluble in water, some loss of the gas would be averted by re-using the nitrous-saturated water from previous fillings. A slight positive pressure could be sustained by not-quite balancing the weight of the container with the counterweights, of which this model has two. A Divine gasometer is mentioned in Figure 1. Divine patented the suggestion that impure nitrous oxide (containing irritating nitrogen oxides) could be detoxified by means of scavenging reagents (potash and iron sulfate) added to the liquid water upon which the moveable can was suspended.

Divine was an inventive person, and his many patents included explosives, a flail for threshing wheat, a musical whistle, and a fruit-shipping container. Colton was also an eclectic entrepreneur<sup>20–22</sup> and invented an electric train powered by its rails.<sup>2</sup> They likely felt a kindred spirit. In anesthesia history, Colton participated in the discovery of nitrous anesthesia, and the commercial success of the

Colton Dental Association dispelled the misperception of nitrous anesthesia as a mere amusement.<sup>2,3</sup> Divine was his noteworthy ally.

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ESTABLISHED 1844.

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**Fig. 6.** Goodyear's India Rubber Glove Manufacturing Company advertised in the Divine booklet of 1867.<sup>4</sup> Self-taught American chemist Charles Goodyear (1800–1860) patented vulcanized rubber in 1844, the year the eponymous glove firm was established.

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